

# THE SPECIES-GROUP OF VESTALIS AMOENA SELYS, 1853, IN SUNDALAND (ODONATA, CALOPTERYGIDAE)

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## ABSTRACT

The present paper deals with a single section of the "Vestalis complex", which still presents a number of problems in classification. The most recent contribution to a general treatment, based on neural and penile characters, is the one given by MAY (1935), who recognized three genera, *Vestalis* Selys (1853) s.str., *Vestinus* Kennedy (1920a) and *Vestalaria* May (1935). Much of importance has since been added to our knowledge of these insects, with which both KENNEDY and MAY were insufficiently acquainted. It was found that the sectional characters of *Vestinus* are almost as unstable as those separating the three vestaline genera distinguished by MAY, and that they exhibit characters of structure and venation which are variously mixed, leading over from one section (or series) to another. In view of this, there seems to be little reason for retaining generic or even subgeneric groupings within the limits of the basic genus *Vestalis*. A clarification of the taxonomy and relationship of the whole complex can not be undertaken before critical treatments of other species-groups have also been given. A detailed analysis of the section *Vestinus*, typified by *V. gracilis* (Ramb.), reveals that it is composed of different elements, at least one of its components, the well-known taxon *V. amoena* Selys, breaking up into 7 closely similar species. This group is centred in Sundaland, and in various places its members occur sympatrically. The sexes are similar and all species have uniformly coloured bodies and wings. Differences in venation and male penis structure are too slight to ensure species recognition. Reliable specific characters are almost exclusively found in the male anal appendages, which have proved remarkably constant; however, in the majority of species females have remained inseparable. The types of the most widely distributed species, *V. amoena* and of that of *beryllae* (Borneo) are redescribed, and definitions based on new characters are given of 6 new species, viz. *V. amethystina* (Malaya, Sumatra), *amaryllis*, *amabilis*, *amnicola*, *atropha* and *anacolosia* (all from Borneo). A key to the males is also given, the descriptions and notes that follow being accompanied by illustrations of the male reproductive organs. The main venational characteristics as well as detailed body-measurements are given for each taxon in tabular form. Special attention is drawn to the distribution records and maps. Sympatric occurrences in various parts of Sundaland are emphasized and tabulated separately. The paper is concluded with an illustrated account of the immature stages, which are compared with those of allied genera, the larvae of *Neurobasis* and *Echo* being also figured.

## INTRODUCTION

The family Calopterygidae is represented in the Indo-Australian Archipelago only by three genera, viz. *Neurobasis* Selys, *Echo* Selys, and *Vestalis* Selys, all of them participating in the calopterygid fauna of the Asiatic mainland as well. *Neurobasis* comprises several polytypic species, which occur from India to China and through Sundaland eastwards far into the Papuan Region. *Echo*, on the other hand, occupies a much more restricted area, the distribution of the two regional species for some reason having been retarded, both being confined to the submontane zone

and hill forests of the Malay Peninsula and the island of Sumatra. With regard to *Vestalis*, it can be said that an analysis of all defined taxa and available material would result in an estimated total of about twenty recognizable species and sub-species distributed all over eastern Asia. Up to the present time, however, the genus only held two major species-groups each with three species, which have succeeded to spread in a southeastern direction into Sundaland. These are enumerated hereafter under A and B. Only a single insular species belonging to group A (*V. melania* Selys), has reached the Philippines, all others being abruptly brought to a halt before or at "Wallace's Line", as first defined by HUXLEY.

ED. MAY (1935) has divided the genus *Vestalis* in three units, which are characterized and treated by him as full genera. These are:

- A. *Vestalis* Selys (1853), s.str., with three species: (1) the genotype *V. luctuosa* (Burm.), of Sumatra, Java and Bali; (2) *V. lugens* Selys, of Malaya (?), Sumatra and adjacent islands; and (3) *V. melania* Selys, of the Philippines. This comprises a group of conspicuously coloured species with broad, densely reticulated wings. All are sexually heterochromatic, males possessing deeply pigmented, beautifully iridescent wings.
- B. *Vestinus* Kennedy (1920b), with four species: (1) the genotype *V. gracilis* (Ramb.) cum subsp., from India to Malaya; (2) *V. apicalis* Selys, terr. typ. "Inde or."; (3) *V. amoena* Selys, from somewhere in Sundaland; and *V. beryllae* Laidlaw, confined to Borneo. — A heterogeneous group of slender species with narrower wings and more open venation. Sexes isochromatic, wing-membrane frequently iridescent but poorly coloured.
- C. *Vestalaria* May (1935), with three or more species, the genotype being *V. smaragdina* (Selys), from Assam. — Both sexes with hyaline wings, which are more broadly sessile and even less closely veined than in B.

In the next pages only the characters of the less strikingly coloured representatives of the section B, i.e., the cluster here called the "*Vestalis amoena* species-group" will be discussed in some detail, no further mention being made of *V. gracilis* and *apicalis*, for which *Vestinus* was originally proposed.

For a general survey of the entire group reference should be made to MAY (1935), and for the regional (Malaysian) members of the family to LIEFTINCK's "Handlist" (1954).

#### CRITERIA OF GENERIC DISTINCTION

MAY already admitted that *Vestalis*, *Vestinus* and his own new taxon *Vestalaria*, though re-defined and treated by him as full genera, are rather artificial units which cannot possibly be classified into 'primitive' or 'specialized' types. Indeed, any sequence indicating an evolutionary trend is virtually impossible because such a classification depends entirely on the criteria used. These criteria are still of a purely morphological nature, being found in the mouth-parts, penile structure, and wing venation. When considering the component parts of *Vestalis* in a broad sense, they show a curious mixture of allegedly generalized and advanced characters. For instance, as was pointed out to me by Mr. J. COWLEY in a personal communication,

the form of the clypeus affords a reliable character to distinguish between species or even species-groups. However, in *Vestalis* s.str., I have recently found that all three species not only possess a very differently shaped clypeus, but the structure of this part of the head in the genotype, *V. luctuosa*, is undifferentiated and almost exactly similar to that seen in the members of *Vestinus*.

As we will see, one species not quite fittingly assigned to the section *Vestinus*, i.e., *V. amoena* Selys, is itself a composite unit whose members have in common that their venational and penile characters are practically identical. With regard to the venation, it should be remembered that MAY separated his three genera on the basis of the origin of the veins  $M_3-M_4$  and the breadth of the  $Cu_1-Cu_2$  area. Now further investigations have proved that the characters employed by MAY

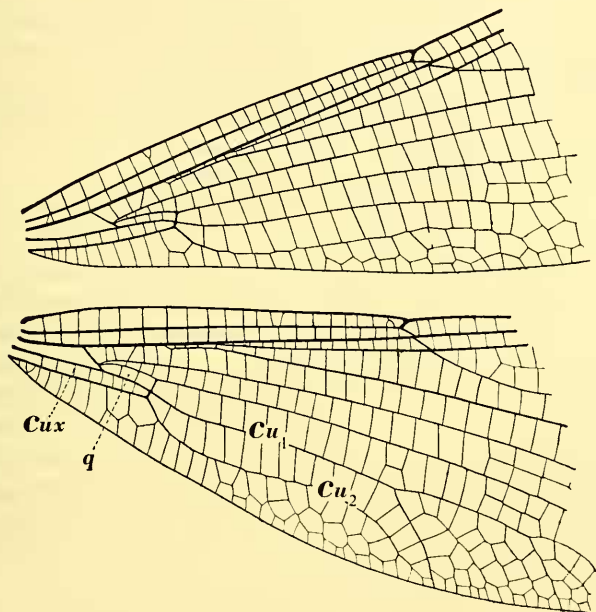


Fig. 1. *Vestalis amoena* Selys, ♀ from South Sumatra. Base of right pair of wings

should be used with caution. Within the limits of the species-group here treated, I found these neural characters to be unstable and leading over to the other two of MAY's genera in at least half of the members at present known. Fig. 1, of the basal part of the wings of *V. amoena*, may serve as an example of the wing venation characteristic for this cluster of forms. It is true that the wings of the rather aberrant *V. beryllae* are narrower than those of the rest but the venation conforms to the same plan. Despite the mainly unisexual characters which separate *V. beryllae* from the remainder, there can be no doubt that all of them are nearly related and are best kept together. If we were to accept *Vestinus* as generically distinct from *Vestalis* on neural characters alone, we would be obliged to detach not only the

compact *amoena*-group from the *gracilis* assemblage but *beryllae* as well, placing each of them in separate units, a conception to which I feel strongly opposed.

A divisional treatment here becomes still more complicated when the male penile organ is examined. Whereas the structure of the penis in the *amoena* group deviates but little from that of *gracilis*, this organ in *V. beryllae* is, remarkably enough, altogether different in shape from that of the rest. It would seem, therefore, equally unjustifiable to base any group characters on the penis structure alone.

Mr. J. COWLEY informs me in a letter that certain other sectional elements of *Vestalis*, examined by him some years ago, were also found to be composite and standing equally in need of re-adjustment.

Taking into account all above facts, I consider it unwise to recognize a great number of genera containing only a single or very few species. Until the genus in its broadest sense has been critically analysed and an adequate knowledge has been obtained of the taxonomic relations within its own limits, I prefer to employ the term species-group, the equivalent of RENSCH's "Artenkreis", for all sections so far denominated or presently recognized. I have not even adopted a subgeneric arrangement, the less so since little or nothing is yet known of the physiological requirements and ethology of the various components.

#### THE SPECIES-GROUP OF *V. amoena*

The most widely distributed amongst these is the insect hitherto called *Vestalis amoena* Selys, 1853. As hinted at already above, this well-known Malaysian taxon breaks up in a number of intimately allied yet clearly definable species. They bear a very close *prima facie* resemblance to each other, being approximately of the same size and having all of them the four wings uniformly tinted, a combination of features not shared by any of the other *Vestalis*. The sexes are similar and have the body of an intense emerald-green, the abdomen often rather more golden or bronze, and both possess semi-transparent wings with a delicate purplish or lilac iridescence. LAIDLAW (1915b) has described a close relative with similar characters from Borneo. This is *Vestalis beryllae* Laidlaw, chiefly remarkable by the great relative length of its abdomen, at least so in the male.

All members of the group are shade-loving jungle insects that breed in small streams and brooks. They are usually common where found, and juveniles may be found some distance from running water.

It is the purpose of the present paper (1) to establish the identity of the true *V. amoena* of HAGEN and DE SELYS and redescribe it; (2) to prove the existence of five near allies formerly confounded with it; and (3) to define one more species not previously known, belonging in the same group.

#### GENERAL CHARACTERIZATION AND SEGREGATION OF SPECIES

Both sexes of the collective taxon commonly referred to as *Vestalis amoena* auct. have been accurately described by DE SELYS (1853, 1873), DE SELYS & HAGEN (1854), and FRASER (1929, 1934).

As far as the general morphology, colour-pattern and wing venation are con-



cerned, the existing descriptions above alluded to are applicable to the entire group<sup>1)</sup>).

All authors depended on the characteristic general appearance of this damselfly as sufficing to distinguish it from the rest; and since it is an ordinary-looking insect frequently represented in collections brought home from abroad, it was always taken to stand for a single somewhat variable species. So it could happen that since the time of the original description of *V. amoena*, the finer morphological structures, such as the male sexual organs, were left unnoticed. It is true that the male penile organ of the supposed "*amoena*" was figured and commented upon in some detail by SCHMIDT (1915) and KENNEDY (1920a), but this was done in treatments of a more general character in which sectional units were opposed and *Vestinus* was compared with the more remotely allied constituents of *Vestalis*. The same is true with regard to the venation of which even MAY (1935) was unable to supply any information owing to lack of material of the group.

The discovery of what seemed to be quite constant structural differences in the male anal appendages of these closely similar calopterygids, led me to accumulate as much material as possible and re-examine all available specimens previously assigned to *V. amoena*.

Brief mention may now be made of earlier records in the literature, with comments on the possible identity of the species involved.

In 1873 DE SELYS already commented on the considerable differences in size existing in a number of individuals he examined from the island of Labuan (NW Borneo). Subsequent examination of these animals showed them to represent two species, viz. *amoena* and *amaryllis*. HAGEN (1887) relates to a small series of females in his collection taken at Mindai and Dusson (?) in southeast Borneo. These specimens differed among themselves both in size and colour, one female being exceptionally small (abd. 34 mm, hind wing 30 mm) while in another the arculus sectors are said to be separated basally. I have not seen these insects but our specimens from southeast Borneo pertain to *amoena* Selys and *amaryllis* sp.n. LAIDLAW (1902) recorded *amoena* from Kuala Aring and Gunong Inas in the Malay Peninsula, remarking that they disagree in body and wing colour. The same author in 1903 reports both sexes from southern peninsular Siam (Patani) but gives no details. WILLIAMSON (1904) also recorded the occurrence of the species in Lower Siam (Trong, Khaw Sai Dow Mountain, 1000 ft.), suggesting that the great amount of variation in colour was due to age and sex. I have not been able to examine material from just these localities, but the above specimens almost certainly are conspecific either with *amoena* and/or *amethystina*, or else with the unnamed insect discussed in this paper under "spec. indet." (p. 338). When, in 1915a, LAIDLAW discussed a series obtained by J. C. MOULTON on Mt. Kinabalu, the author was struck by the considerable differences in size exhibited by both sexes, the extremes noted by him in one series of males being 48—52 mm for the abdomen, 37—38.5 mm for the hind wing, whereas the rest of the males measured 44 and 34 mm, respectively. This led LAIDLAW to believe that the species presents

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<sup>1)</sup> Except where some special condition demands mention of them, these general descriptions are not repeated in the specific characterizations which follow.

an example of "discontinuous variation" in both sexes, an untenable suggestion as we will presently see, the Mt. Kinabalu area being inhabited by three quite different species, viz., *amnicola*, *anacolosa*, and *beryllae*.

All remaining articles in which "*V. amoena*" is merely recorded without comment have been omitted from the bibliography at the end of this paper.

Penis structure. — This organ was figured and briefly described for one (or more) species of the *V. amoena* group by SCHMIDT (1915: 144, pl. 11 fig. 45) and KENNEDY (1920a: 29, fig. 46—47), and for related species-groups by MAY (1935: 214, fig. 12—16). The penis is difficult to figure adequately as its terminal parts are twisted and bent in various planes. All were examined in the dried state after relaxing pinned or papered specimens. It was repeatedly found, however, that the penes extracted from a small series of unquestionable conspecific males were nevertheless not exactly alike. It soon became clear that certain feebly sclerotised membranous parts showed various degrees of shrinkage in specimens representing different stages of maturity. In some *V. amaryllis* from SE Borneo, for instance, it was found that the limbus membranous at the apex of the glans was either more or less saucer-shaped and of large size, or reduced to a tiny transverse plate, in others still this lobe being absent altogether. In fact, no two penes of a single species from one locality were absolutely alike as the folding varies and the terminal filaments may project at different angles.

The following brief description applies to all forms except *beryllae*, which has a differently shaped penis. Shaft long and curved, its convex surface sclerotised and strongly pigmented; provided on either side near its apex with a ridge-like outgrowth furnished with bristles, a row of lateral bristles also being present more basad and some way out beyond the position of the ridge. Glans penis with its distal part recurved; lamina interna conspicuous, placed transversely and curled inward; limbus membranous very variable, usually short and ridge-like, occasionally of great size; distal portion provided with a pair of symmetrically placed, deeply bifid, thread-like filaments which are variously curved and twisted but about equally long, the outer branch being provided at its base with a strong, slightly pigmented, spine-like process. Specific differences in the general shape and in the form of the processes could not be detected; even if such differences do exist, they will probably prove too slight to be of diagnostic value. The penes of the three species here figured, viz. *V. amoena*, *amaryllis*, and *anacolosa* (fig. 2) are closely similar to those of all others, with the exception of *V. beryllae*. In the latter the apex of the penis shaft is furnished with a greater number of bristles which are shorter and finer than in the remaining species; here, also, the thickening of the lateral wall at the end of the shaft is replaced by a distinctly hairy, triangular lobe projecting laterad at a right angle. The complicated structure of the apical part of the glans penis of *V. beryllae* is probably best understood from a consultation of the camera lucida drawings I have made of it. A curved lamina interna is present but concealed from view by the greatly developed external branch of the apical process (fig. 10).

Females. — No serious attempt has been made to identify all available females specifically, because it appeared that any colour distinctions are complicated by

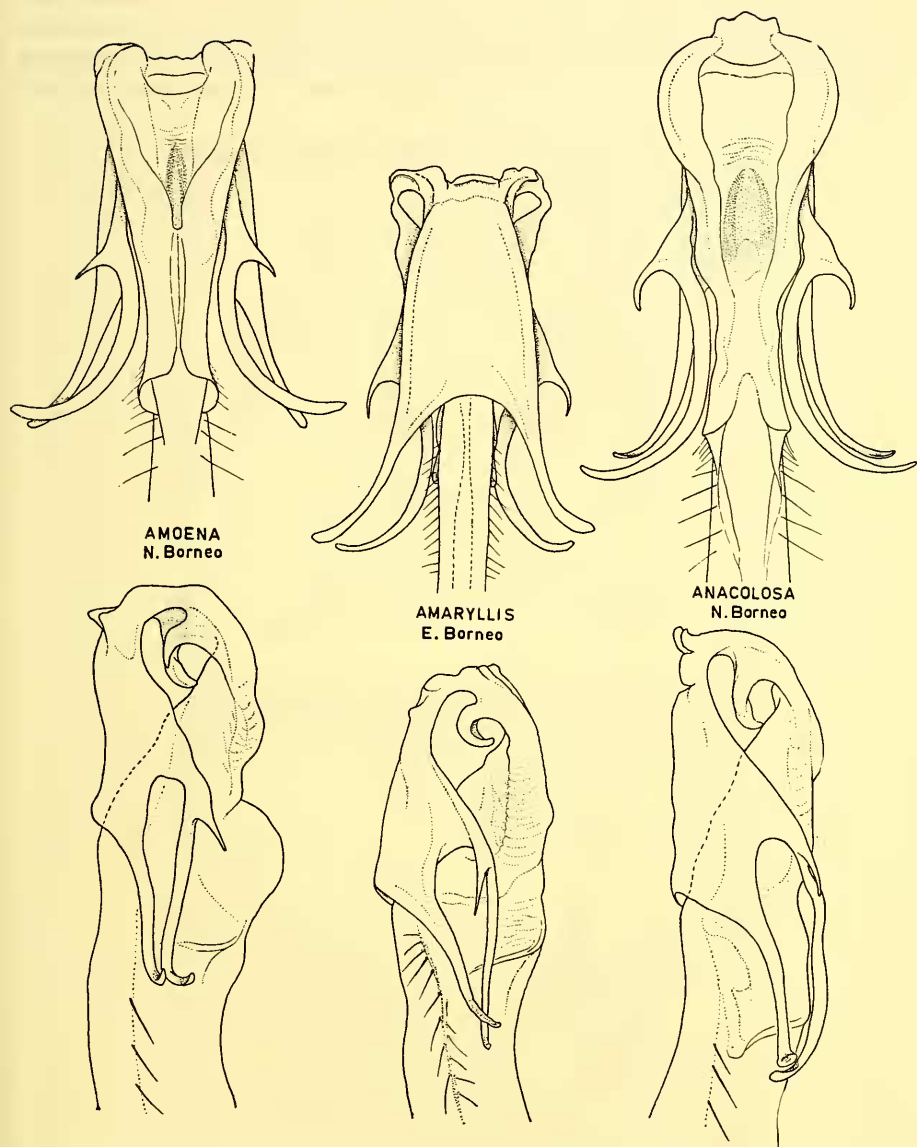


Fig. 2. Apical part of penis of *Vestalis* species. Upper row: dorsal view (*V. amoena* and *anacolosa*) and ventral view (*V. amaryllis*); lower row: right lateral view

differences due to maturity, and good series taken with their respective males are not available. See, however, under each species. Structural differences are not apparent, the form of the clypeus and prothorax as well as the armature of the terminal abdominal segments, valves and appendages being practically the same in all species. The existence of a minute "parorbital" tubercle situated posteriorly on

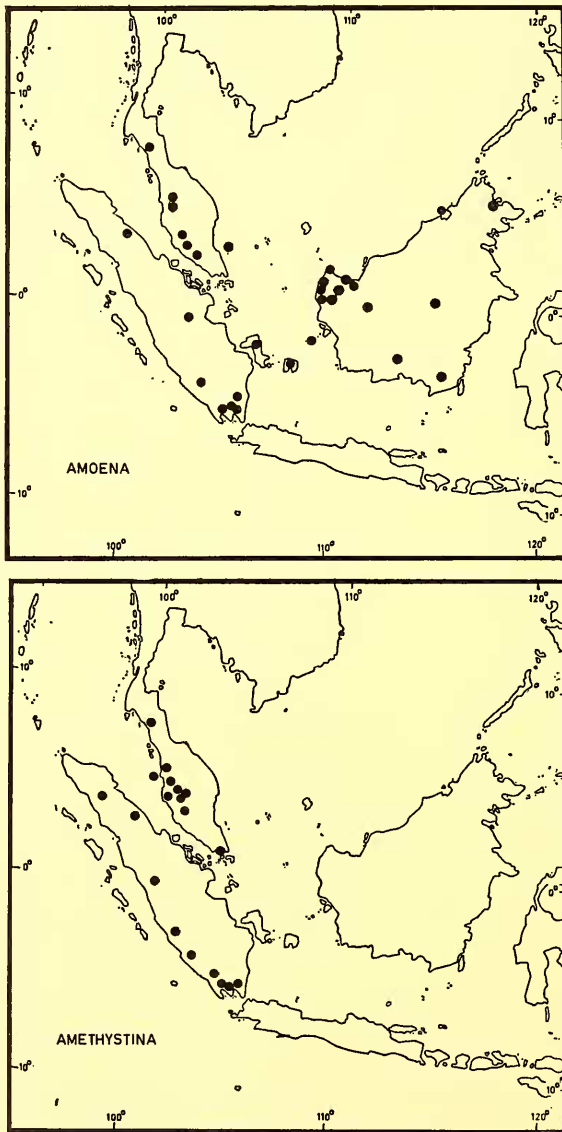


Fig. 3. Geographical distribution of the *Vestalis amoena* group in the Malaysian Subregion, showing all known localities for two species and their sympatric occurrence in the Malay Peninsula and Sumatra



either side at some distance from the inner border of the compound eye, which I first thought might be used as a means of separating species, proved to be individually variable. In a series of *V. amoena* from Borneo it was found to be present in all females, though occasionally poorly developed, while in Sumatran examples it was either extremely minute or absent altogether.

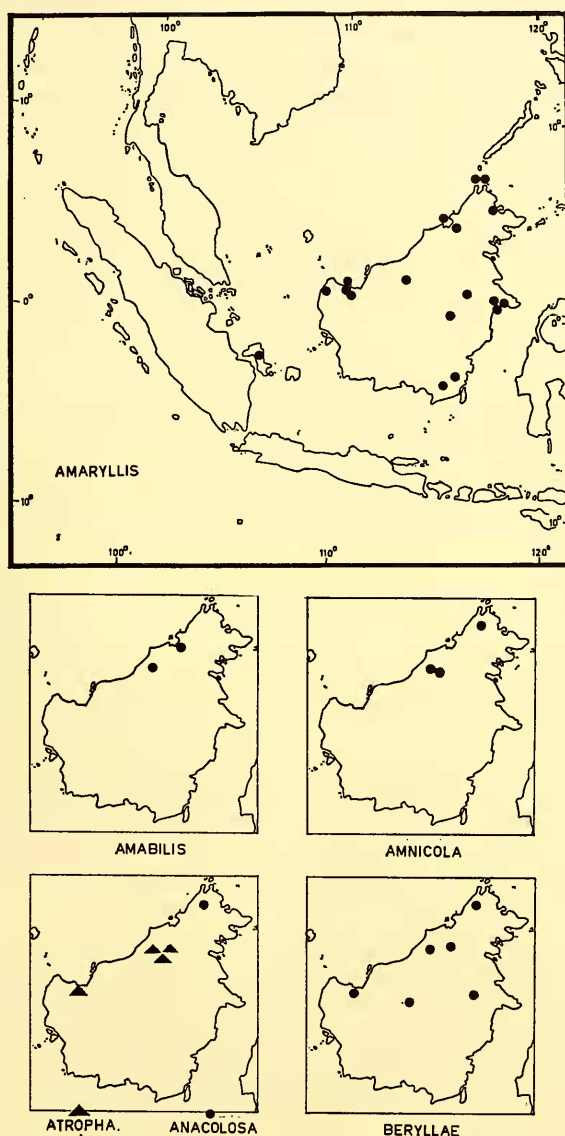


Fig. 4. Geographical distribution of six species of the *Vestalis amoena* group in the Malaysian Subregion, showing all known localities

## SPECIATION AND GEOGRAPHICAL DISTRIBUTION

As constituted at present the section *V. amoena* occupies, roughly, the area called the "Malaysian Subregion"<sup>1</sup>), or, speaking in geological terms, the land-mass known as Sundaland. In this particular case the limits of the distributional area are still more restricted and somewhat arbitrarily defined, because a notable exception is formed by the island of Java (and Bali) whence no species are known with certainty. For a possible explanation of the remarkable absence in Java, even of the wide-spread *V. amoena*, see under that species. The exact limits of a north-western extension of the group into Thailand and Lower Burma are still unknown.

According to the evidence of present-day distribution and specific differentiation, it would seem that the entire group is of western origin and of old standing. It may have had an ancestral continental form which gave rise to the parental stock originating in Sundaland as a side-branch of the *V. smaragdina* and *gracilis* assemblages occurring in India and Indochina. This distribution can perhaps be explained by assuming that the *amoena*-branch followed the major invasion route from Burma and occupied the most suitable parts of Sundaland at a time when the sea-level was still low. If so, the least differentiated and at the same time most widely spread species, *V. amoena*, which has reached Borneo, is older than the rest, the majority of the group having evolved after the islands were severed from the continental block by the rising sea-level in post-pleistocene times. ZEUNER (1943), in his highly instructive work on the systematics and phylogeny of the Australasian genus *Troides* Hübner (s.lat.), has mentioned a group of papilionid butterflies showing a somewhat similar, though less complicated, distribution-pattern. This is the purely Malaysian species-group of *T. amphrysus* (Cramer), which contains four polytypic species of which several are of sympatric occurrence, also in Java.

Whereas the three species of *Vestalis* s.str. are allopatric<sup>2</sup>), the males of each possessing deeply pigmented and brilliantly coloured wings, we have seen that both sexes of all known members of the *V. amoena* group have translucent wings, aged individuals even showing approximately the same amount of faint iridescence and apical obscuration. Although this cluster of intimately allied species are remarkably similar, the males have quite distinctive abdominal appendages by which they can be held apart. Several amongst them live side by side under seemingly identical ecological conditions. Since intermediate forms have never been found, there is every reason to assume that they are unable to interbreed, which is regarded as further proof of their specific distinctness.

All known locality records of the regional species characterized and named in the present paper are entered in the accompanying distribution maps (fig. 3—4), doubtful records and identifications being omitted therefrom. It is obvious from these maps that there occur several species whose ranges overlap, but there exist also some representing each other geographically. For instance, the same two

<sup>1</sup>) For an explanation of the term Malaysia as outlined by BODEN KLOSS, CHASEN, LIEFTINCK, etc., see the writer's "Handlist" (1954).

<sup>2</sup>) Except in the extreme south of Sumatra, where *V. luctuosa* and *lugens* are not uncommonly found together (see LIEFTINCK, 1954).

species, *V. amoena* and *amethystina*, occur sympatrically in the western part of the distributional area comprising southern Thailand, the Malay Peninsula and Sumatra. Only one of them, *amoena*, extends further east into Borneo, where it meets another close ally, *amaryllis*. Although the range of the latter also includes the island of Bangka in the west, it has not apparently succeeded to reach Sumatra and the Malay Peninsula, i.e. the territory occupied by *amethystina*. This distribution suggests that, although both *amethystina* and *amaryllis* are undoubtedly of western origin, the Bornean *amaryllis* had already become isolated and differentiated before *amethystina* could establish itself as an independent species.

Eliminating quite a number of ambiguous cases, all instances where sympatric occurrences of two or more species could be definitely established, are listed in Table I.

Table I. Sympatric occurrences of the *Vestalis amoena* species-group in the western part of the Malay Archipelago

	<i>amethystina</i>	<i>amoena</i>	<i>amaryllis</i>	<i>amnicola</i>	<i>atropba</i>	<i>amabilis</i>	<i>beryllae</i>	<i>anacolosia</i>
Thailand:								
Trang waterfall, same month	+	+						
Malay Peninsula:								
Kuala Lumpur area (Selangor)	+	+						
Sumatra:								
NE Sumatra (Deli)	+	+						
Kedaton (Lampong)	+	+						
Mt. Tanggamus (id.), same date	+	+						
Bangka:								
Lubuk Besar, same date		+	+					
Borneo:								
Mt. Dulit (Sarawak)				+	+	+	+	
Mt. Penrissen (Sarawak)			+		+		+	
Kuching area (Sarawak)		+	+					
Labuan Island		+	+					
Singkawang (W Borneo)		+	+					
Ampah (SE Borneo), same date		+	+					
Long Hut (Kutai), same month			+				+	
Mt. Marapok (Sarawak)			+			+		
Mt. Kinabalu (Sabah)				+			+	+

Borneo is a significant distributional centre which produced no less than 4 other species, all of them peculiar to the island (fig. 4). It is there that the development of the genus culminates in the remarkably specialized *V. beryllae*. Structurally, this species holds an isolated position, recalling that of another Bornean calopterygid, viz. *Neurobasis cyaneipennis* Förster. This has been segregated from the polytypic species *N. chinensis* (L.) under the subgeneric name *Matronoides* Förster.

## ETHOLOGY

JOHNSON (1961), referring also to several earlier writers on breeding behaviour in Calopterygidae, has shown that in *Hetaerina* different wing patterns are important functional requisites in species recognition for conspecific mating. In this and other genera it has, indeed, been experimentally verified that the females recognize and respond to males of their own species through a set of optical stimuli including the colour design of the wing.

With reference to the above, it would seem that the species recognition factors in this clear-winged group of *Vestalis* are mainly the shape of the male appendages and in a few instances (*V. beryllae*) also, perhaps, body colour. It is to be expected that in the sympatric species reproductive isolation is accomplished and maintained by a combination of these structural differentiations and ethologically opposed treats, such as posture, flight- and courtship-behaviour, etc.

## KEY TO THE MALES

1. Abdomen with appendages at least 63 mm long, hind wing  $\frac{4}{7}$  length of abdomen or less. Mouth-parts, antennae and thoracic segments lacking any yellow colouring, the sutures black. All abdominal segments brilliant metallic green; sup. app. black. Penis shaft with triangular process on either side near apex; glans wide, its distal portion short and shield-like carrying a pair of twice folded, elaborately twisted and frilled basal lobes (outer branches) and ending in a pair of simple lanceolate flaps (inner branches) (fig. 10). Anal app. broader and more flattened than in the allied species (fig. 10). Hab. Borneo . . . . . *beryllae*
- Abdomen with appendages not exceeding 51 mm, hind wing about  $\frac{3}{4}$  length of abdomen. Only basal segments of abdomen metallic green, turning to bronze-black or black posteriorly. Penis shaft with low transverse ridge on either side near apex; glans narrower, its distal portion much longer than wide in ventral view, ending in a pair of long biramous filamentous lateral processes, the basal ones (outer branches) carrying a short spine, the apical (inner branches) simple (fig. 2) . . . . . 2
2. Inf. app. rudimentary: lateral processes reduced to blunt subtriangular tubercles (fig. 7, 9). Labium black, only palpiger and 1st palpal segment yellow exteriorly; mandible-bases with isolated squarish spot. Labrum dark metallic black. Basal half to  $\frac{2}{3}$  of 2nd antennal segment yellow anteriorly. Female unknown. Hab. N Borneo . . . . . *anacolosa*
- Inf. app. at least half as long as superiors, broad at base, ending in long slender lateral processes . . . . . 3
3. Distal portion of inf. app. relatively short and thick, straight and cylindrical, not reaching back quite as far as the subapical projection of sup. app. (fig. 5, 9). Sup. app. with a single obtuse-angulate interior tubercle before apex, the upper surface of which is slightly wrinkled but neither scalloped nor deeply emarginate and devoid of tooth-like inner projections. Labium predominantly yellow tipped with black; mentum partly and median lobe on either side of the



middle frequently obscured but never black; stipes of maxilla usually pale. Mandible-bases yellow. Labrum at least partly yellow, very rarely entirely metallic black. Yellow mark on anterior face of 2nd antennal segment almost or quite reaching apex of same, though frequently reduced to a basal spot; very rarely absent altogether. Thoracic sides and ventral surface at least partly with yellow colouring on infraepisterna, lower parts of metapleura and poststernum, these yellow areas occasionally obscured or concealed from view by grey-blue pruinescence. Hab. Malaya to Borneo . . . . . *amoena*

— Distal portion of inf. app. distinctly longer with more slenderly incurved apices, though occasionally degenerated and filiform. Labium predominantly black, only palpiger and 1st segment of palpus narrowly bordered with yellow outwardly; stipes of maxilla usually obscured. Lower parts of thoracic sides largely obscured and poststernum wholly black . . . . . 4

4. Sup. app. with a single obtuse-angulate interior tubercle before apex, which is more expanded and hollowed out ventrally, than in *amoena*; upper surface of apex with inner edge not prolonged cephalad, neither ridge-like nor emarginate within (fig 5, 9). Inf. app. very slender, reaching back as far as subapical projection of sup. app. or even a little further. Mandible-bases with isolated yellow spot. Labrum metallic black, unmarked with yellow. Anterior face of 2nd antennal segment entirely black or with small basal yellow spot. Thoracic sides and ventral surface lacking yellow spots, the yellow stripes bordering second suture and latero-ventral margin of metepimerum linear or obliterated. Hab. Borneo . . . . . *amabilis*

— Apex of sup. app. more cylindrical in outline (not bluntly triangular with inwardly bent tip), distinctly hollowed out within when viewed from above, the outer portion being on a higher level than the inner; inner margin in dorsal view continued cephalad as a gradually more swollen ridge that curves at first outwards and then inwards so as to enclose a tiny hollow, the ridge itself ending abruptly in a blunt tooth or knob; in ventral view the subapical tubercle is either single or differentiated to form tooth-like projections. Inf. app. very slender, of variable length and strength . . . . . 5

5. Inf. app. of the usual breadth basally but soon narrowed to form extremely thin, shrivelled, thread-like processes reaching back scarcely as far as the interior subapical tubercle of sup. app., which is strongly protuberant; distal portion of sup. app. drawn out, gently upcurved (fig. 8). Labrum metallic black, lacking yellow spots. Mandible-bases with isolated basal yellow spot. Anterior face of 2nd antennal segment black or with vestigial basal yellow spot. Lower parts of thoracic sides black; yellow stripe bordering second suture and latero-ventral margin of metepimerum linear and/or obliterated. Small, narrow-winged species with a maximum of 53 postnodal cross-veins in fore wing, 43 in hind wing. Female unknown. Hab. Borneo . . . . . *atropha*

— Inf. app. long, less emaciated, reaching back as far as interior projection of sup. app., the latter shorter, more evenly incurved. Postnodal cross-veins 53—81 in fore wing, 44—60 in hind wing . . . . . 6

6. Apical portion of sup. app. rather broad, the interior projection prominent though simple and broadly rounded, the surface beyond it smoothly concave

- ventrally and bounded apically by a low transverse ridge; no pronounced ridges or projections, the apex itself more or less oval (fig. 7, 9). Labrum metallic black, occasionally with vestigial yellow spot on each side. Anterior face of 2nd antennal segment with basal yellow spot attaining  $\frac{1}{3}$  or less of whole length. Narrow yellow stripes, incomplete on both ends, bordering second suture and latero-ventral margin of metepimerum. Apices of wings more drawn out and tips more pointed than in allied species. Hab. Borneo . . . . . *amnicola*
- Apical portion of sup. app. narrower, of complex structure interiorly. Labrum invariably marked with yellow . . . . . 7
7. Ventral tubercles preceding apex of sup. app. relatively small, ridge-like tip of appendage projecting far beyond apex of inf. app. (fig. 6, 9). Anterior face of 2nd antennal segment entirely yellow or almost so. Lower parts of thoracic sides usually with some yellow colouring on infraepisterna, metapleurae and coxal bases; yellow stripes bordering second suture and latero-ventral margin of metepimerum distinct, though occasionally incomplete. Hab. Malaya and Sumatra . . . . . *amethystina*
- Ventral tubercles preceding apex of sup. app. well-developed, especially the distal one in the form of a prominent tooth; inf. app. relatively longer (fig. 6, 9a). Anterior face of 2nd antennal segment either entirely yellow or only the basal half to one-third coloured thus. Lower parts of thoracic sides with traces of yellow only, or entirely black; stripes bordering second suture and latero-ventral margin of metepimerum likewise variable, often linear, obliterated, or even obscured so much as to become scarcely discernible. Hab. Bangka and Borneo . . . . . *amaryllis*

*Vestalis* spec. indet.

Material. — Burma: 1 ♂ (ad.), Tenasserim, Mergui (Mergwe) Archip., King Island, 23.VI.1927, J. ELTON BOTT, ex coll. F. C. FRASER (BM).

Light chrome yellow are the following parts: the entire labium including the median lobe, only the tips of the palpi being black; visible parts of the maxillae; basal two-fifths of mandibles including the trochantins; labrum with the exception of a diffuse mid-basal spot and a stripe along anterior border, widest in the middle; a mid-basal spot on anteclypeus; whole anterior surface of 2nd antennal segment. Anteclypeus, genae and a narrow stripe, tapering upwards, along margin of compound eye, black. Rest of the head brilliant emerald green; rear pruinescent grey-blue. Lower margin of propleuron narrowly yellow. Median carina, humeral and first lateral sutures finely black. Most of the infraepisterna, lower parts of mesepimera and metapleurae below level of spiracle, as well as the entire ventral surface of synthorax, coxae and trochanters, yellow; elongate metallic green patch covering most of the metepimerum abbreviated ventrad, the yellow stripe along second suture twofold. Lower areas of thorax pruinescent.

Wing membrane hyaline; nodal index  $\frac{50.25.26.52}{45.21.22.45}$ ;  $q \frac{3.4}{3.3}$ ;  $cux \frac{9.11}{9.9}$ ; one cell-row  $Cu_1 - Cu_2$ .

Anal appendages shaped much as in *V. amoena* but the superiors less incurved and more drawn out; inferior appendages longer and slenderer.

Measurements: abd. + app. 47.3 mm, hind wing 36.0 : 8.4 mm.

I believe this specimen to represent a distinct new species. It is unfortunately the only individual of the group from outside the Malaysian Subregion examined by me. To name it at this time might result in confusion for subsequent authors as it is not in too good a condition, its terminal appendages, moreover, being distorted and unfit for figuring.

*Vestalis amoena* Selys, 1853

(fig. 1, 2, 3, 5, 9)

Material. — Lectotype ♂ (incomplete), hab. ign., labelled: "? Java", see below (MCZ). — Thailand: 5 ♂ (one with abdomen missing), with printed labels: S. Siam, Trang waterfall, 9, 21 and 23.VII.1935 and 7.VIII.1935, Dajak LAYANG GADDI coll., R. Mus. Hist. Nat. Belg. I.G. 10.688 (IRSN). — Malay Peninsula: 1 ♂ 1 ♀, "Malacca" (yellow, DE SELYS' writing); 1 ♀, "Mt. Ophir" (white disk), "Malacca" (yellow, DE SELYS' writing) (IRSN); 1 ♂ (juv., wings defective), "Malacca" (DE SELYS' writing) (IRSN); 1 ♂ (juv., wings defective), "Malacca" (DE SELYS' writing, orange label), "*V. amoena* Malacca", ex coll. & det. MACLACHLAN, and "Paratype" (BM); 1 ♂, Perak, 4 miles N of Kp. Lasah, Sungai Chior (Chior Big Game Forest Reserve), 9.IV.1964, J. I. FURTADO (ML); 1 ♂, Selangor, Sungai Rumpit (tributary of S. Gombak), 5.I.1964, J. I. FURTADO (ML); 1 ♂, Selangor, Sungai Gombak, 16th mile Kuala Lumpur-Bentong road, 13.IV.1964, J. I. FURTADO (ML); 2 ♂, Selangor, Kuala Lumpur, brook in rubber garden, 2.III.1962, G. F. MEES (ML); 1 ♂, Negri Sembilan, Malay Peninsula, H. N. RIDLEY (BM). — 2 ♂, Pulu Tioman, Sedagong, V.1927, ex coll. F. C. FRASER (BM). — Sumatra: 7 ♂, Ost Sumatra, A. HEYNE vend. 1919, *V. amoena* det. F. RIS (SMF); 1 ♂, NE Sumatra, Serdang, Tandjong Morawa, B. HAGEN (ML); 1 ♀, Inderagiri, Pangkalan Kasai-Sebrida road, 15.IV.1939, P. BUWALDA (ML); 2 ♂, "Sumatra Weijers", "M. Weijers Westkust Sumatra" and "*V. amoena*" (all in DE SELYS' writing) (IRSN); 6 ♂ 3 ♀, Palembang, Mt. Dempo, 700 m, Pagar Alam, 23.V.1935, M. E. WALSH (ML); 4 ♂ 1 ♀ (1 ♂ app. drawn, fig. 5, 9; ♀ wing-bases, fig. 1), Lampong Distr., foot of Mt. Tanggamus, Giesting, 400 m, 24 & 27.XII.1934 and Wai Berah, 28.XII.1934, M. A. LIEFTINCK (ML); 1 ♂, same loc., 17.VI.1934, L. J. TOXOPEUS (ML); 2 ♂, E. Lampong distr., Menggala, Terbanggi-ilir, 14 & 19.VIII.1936, M. BARTELS; 2 ♀, Lampong distr., Kedaton Estate, 150 m, 23.III.1937, J. v. D. VECHT; 1 ♂, same area, Kasui, 23.VIII.1933, H. R. A. MULLER (ML). — Bangka I.: 3 ♂, Lubuk Besar, 20 m, IX-X.1949, A. J. KOSTERMANS (ML); 1 ♀ (juv.), Petaling, 18.II.1932, J. v. D. VECHT (ML). — Billiton I.: 1 ♂, Central Billiton, Begantung, 23.VIII.1935, F. J. KUIPER (ML); 1 ♀ (juv.), W. Billiton, Tjerutjuk, 22.II.1937, F. J. KUIPER (ML). — Borneo: 1 ♂ (penis drawn, fig. 2), Brit. N Borneo (Sabah), SW part of Sandakan Bay, Sapa-gaya Lumbering Camp, 6.XI.1957, J. L. GRESSITT (ex BISH, ML); 10 ♂ 4 ♀ (sub *amoena*), labelled "Labuan Borneo", or "Labuan" (yellow, DE SELYS' writing) (IRSN); 1 ♂, Labuan Borneo, *Vestalis anoena* Hagen, Borneo, ex coll. & det. H. ALBARDA (ML); 1 ♂, labelled "Labuan" (yellow, DE SELYS' writing), "*Vesta-*

*lis amoena* Hag. ♂ Labuan" (id.), "Hagen" (white, printed) (MCZ). 1 ♂ (juv., app. missing) 1 ♀, W Sarawak, SE of Kuching, near Serian, Tapuh, 6-9.VII.1958, T. C. MAA (ML); 2 ♂, extreme W Sarawak, kampong Poëh, 1—2.VI & 6—13.VI.1958, T. C. MAA (BISH, ML); 3 ♂ (one with last abd.-segm. missing), W Sarawak, Merirai valley at Rajang river, nr. Kapit, 600 ft., secondary forest, 28.VII—6.VIII.1958, T. C. MAA (BISH, ML); 2 ♂, same area, Nanga Pelagus, 600—1750 ft., 7—14.VIII.1958, T. C. MAA (BISH, ML); 1 ♀, Sarawak, Kuching, 27.VI.96, ROLLE vend., *V. amoena* det. F. RIS (SMF); 2 ♀, Central E. Borneo, Kutai, Bloë-oe, 26.IX.1894, Borneo Exped., Dr. NIEUWENHUIS (ML). 15 ♂ 4 ♀, Southeast Borneo, Kandangan, Ampah, 0—20 m, IV—V.1948, LIEM SWIE LIONG (ML, MCZ); 2 ♂, South Borneo, Sampit area, Sungai Sampit, 12.I.1950, W. BUYN (ML); 1 ♂ (def.), West Borneo (BM); 1 ♂ 2 ♀ (1 ♀ juv.), West Borneo, Sintang, "Wald", 2.III, 4—16.IV.1910, Dr. L. MARTIN (SMF); 9 ♂ 6 ♀, West Borneo, environs of Singkawang: Piong San road, 9.XII.1931 (♂), Bengkajang road, 16.XI.1931, 30.XII and 11.X.1932 (3 ♀), Bakuan, Selakau river, 22.I.1934 (1 ♀), forest marsh near Bakuan, 7.XII.1931 & 15.IX.1932 (1 ♂ 1 ♀), Penaring boundary, forest stream, 21.XII.1931, 28.I—8.II.1932 (7 ♂ 1 ♀), all L. COOMANS DE RUITER (ML). — 3 ♂ 3 ♀, Karimata I., off SW Borneo, Sungai Palembang, 26.III.1931, L. COOMANS DE RUITER (ML).

*V. amoena* was first described by DE SELYS LONGCHAMPS in the Synopsis (1853: 25—26) after a male and female from "Sumatra", ex coll. SCHNEIDER and WESTERMANN, respectively. In the Monographie (1854: 82—83), which appeared under the joint authorship of DE SELYS and HAGEN, a more detailed description of these two individuals is given and their origin specified. The male from "Java", acquired by SCHNEIDER from DE CHARPENTIER, was submitted to HAGEN who himself prepared the description and gave it to DE SELYS for incorporation in the Monographie. The female from "Pulo Penang" in WESTERMANN's collection most likely belongs to *amethystina* but will not concern us here. In the 3rd Additions to the Synopsis (1873: 475), DE SELYS declares that: "c'est de Malacca et de l'île du prince de Galles [Penang] que j'ai reçu les types décrits précédemment". The proper habitat of the type specimen thus being not definitely known we have to take our choice between the islands of Sumatra or Java, and the Malay Peninsula.

The type (lectotype by present designation) is a male in dilapidated condition. The head (detached and found loose in the drawer) has been glued on to the prothorax; the abdomen is broken in two places and subsequently mended (segments 6 and 8—9), the segments 7 and 10 + terminalia are missing. The total length of the rest of the abdomen is 37.3 mm, of the hind wing 34.5 mm. The specimen bears the following labels: "Java" (written on old white label, perhaps in T. DE CHARPENTIER's writing); "Charp." (written on old white cadre, perhaps in SCHNEIDER's hand); "*V. amoena* \*Hag." (HAGEN's writing on old white black-framed cadre), with "not type, Banks" written in the corner; "Hagen" (small print); "Type MCZ no. 30.907".

As indicated above, the lectotype may or may not have come from Java. The locality given is probably erroneous, or at least unreliable, as the species has never turned up again in that island (LIEFTINCK, 1934). In my "Handlist"



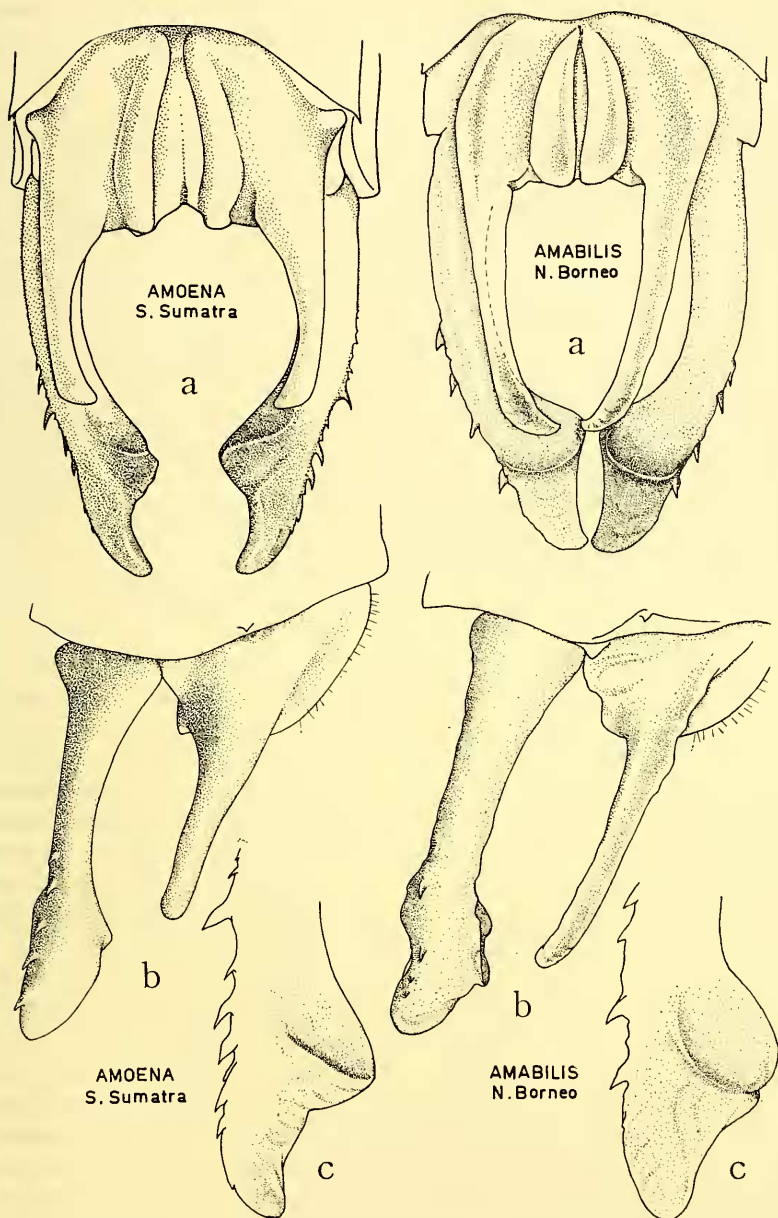


Fig. 5. Anal appendages of *Vestalis* species. a, ventral, b, right lateral view; c, apex of left superior appendage more enlarged, dorsal view

(1954) I suggested that it still awaits re-discovery in Java or may have occurred there and become extinct, the last possibility being the most likely one. The two other specimens in the same collection are from Labuan, but these are of much later date than the type and therefore of less importance. The young male from

"Malacca" in the British Museum collection (ex coll. MACLACHLAN), labelled "paratype", also originates from DE SELYS' collection and may stay as a paratype of *V. amoena*.

Despite a slight discrepancy in the first description of the superior anal appendages of the male, which are said to be "presque bifides à leur extrémité", I believe to have correctly associated our specimens with the type, now lacking its terminalia. This has the stipites of the maxillae as well as the entire basal half of the labium yellow, only the disk beyond the yellow mentum being obscured; this is a distinctive feature of all individuals here assigned to *amoena* serving to separate it from its allies. The sides of the thorax have much yellow on the lower parts, most of the ventral surface also being yellow. The stripes along the second suture and latero-ventral margin of metepimerum are moderately broad, the former being narrowly interrupted by black on both ends. In the majority of our specimens, regardless of locality, these yellow stripes are even wider, the first one often being twofold, i.e. joined to a somewhat shorter metepisternal hair-line. The wings of the type are quite clear, there being no marginal obscuration at the apices so frequently observed in old adults. The principal characters of the venation are summarized in Table II. Those of the type are:

$$\text{cross-veins in } q \frac{3.4}{3.3}; \quad \text{nodal index } \frac{62.25.27.65}{-21.24.-}.$$

Further material. Male. — The extent of black marks on the labrum varies considerably throughout our series, though in the majority the yellow basal stripe is narrowly interrupted in the median line so as to form a T-shaped black mark. A few old males from Ampah (SE Borneo) show no trace of yellow but these are rare exceptions. In them all light body marks tend to become obliterated: only the basal two-thirds of the 2nd antennal segment remains yellow anteriorly, the thoracic stripes are linear and the under surface of the thorax becomes blackish. Should the appendages not be in good condition, such individuals can be recognized only by the palpus being more broadly spotted than in any other species.

The two males from Tioman Island average larger in size than those from other regions and have a correspondingly higher nodal index. In the hind wings of one there are irregularly two rows of cells between  $Cu_1$ — $Cu_2$ . They agree with other Malayan specimens; in one the labrum carries a pair of transverse yellow spots, in the other it is unicoloured greenish black. On the other hand, the few specimens from Bangka and Billiton, are relatively of small size, agreeing in this respect with those from Ampah in SE Borneo. Some evidence to the contrary can be observed in a population occupying the Karimata group of small islands, off SW Borneo, where the insects are superior in size to those occurring on the opposite mainland.

With age the wing membrane in both sexes becomes dusky around the margins and at the tips, in some old individuals the whole wing acquiring a greyish-brown tint.

The superior anal appendages are not unlike those of the Indian species *Vestalis gracilis* Ramb. and its immediate allies, a group of forms also agreeing with *V. amoena* in having the inferior pair relatively short and thick. In the Malaysian

*V. amoena* the oblique transverse carina of the superior appendage is always well-developed on the dorsal as well as on the ventral surface, ending at a point where the subapical expansion is widest, or extending roundabout the latter. These ridges are, however, not precisely similar in all populations examined: in Malayan and Sumatran specimens the dorsal carina is placed a little more transversely than in those from Borneo, though in all of them the appendage on both sides of the dorsal ridge is hollowed out (fig. 5, 9). The short and robust form of the inferior appendage is quite constant and serves to distinguish the species from the much scarcer *V. amabilis*.

Female. — The labium is invariably yellow, only the tips of the palpi and (more rarely) also of the midlobe being black. The labrum usually carries a black point in the middle at base besides having the anterior border black; only in about 14% of the total the light colour is more restricted, the labrum then bearing a T-shaped black mark. There is often a median spot of yellow on the anteclypeus. The lower surface of the thorax remains yellow even in aged individuals though bluish pruinescence may conceal or obscure the light colours.

Size very variable. Male (see Table III). The dimensions of Bornean females are: abd.+app. 35.0—39.0 mm, hind wing 31.0—36.0 mm. It is worth mentioning that considerable individual variation exists in the proportionate lengths of abdomen and hind wing, the difference in length in our series from Borneo varying from 2.5 to 6.0 mm, with an average of 3.4 mm.

*Vestalis amethystina* spec. nov.

(fig. 3, 6, 9)

Material. — Thailand: 3 ♂ 1 ♀ (ad., indet.), S. Siam, Trang waterfall, 20.VII.1935, Dajak LAYANG GADDI coll., R. Mus. Hist. Nat. Belg. I. G. 10.688 (IRS.N). — Malay Peninsula: 1 ♂ (sub *amoena*), Malacca (yellow label, DE SELYS' hand), 27, *Vestalis amoena* 1 exempl. M. TILLYARD (unknown writing) (IRS.N); 1 ♂, Kedah, Kedah Peak, 22.VIII.1937 (BM); 2 ♂ 7 ♀, Wellesley, Penang I., Batu Feringgi, Catchment Area, 2—500 ft., 23.II, 31.V, 2.VI, 1.VII, 31.VII.1960, and 2 ♀, Sungai Pinang, 1500 ft., 12.III & 24.VII.1960, H. T. PAGDEN (ML); 2 ♂, Perak, Ding Ding Is. & Dindings, H. N. RIDLEY (BM); 1 ♂, Perak, Batang Padang, Jor Camp, 1800 ft., 4.VI.1923, H. M. PENDLEBURY, ex coll. F. F. LAIDLAW (coll. J. COWLEY); 1 ♂, Perak, Jor, 4.VI.1923, *V. amoena*, det. F. F. LAIDLAW (coll. J. COWLEY); 1 ♂, Perak, Taiping Pass, 1000 ft., 9.VI.1937 (BM); 1 ♂, Perak, 14th mile, Cameron Highland's road, 11.000(?) ft., 12.IX.1937 (BM); 1 ♂ (juv.), Perak, Ipoh, Kramat Pulau, 23.IV.1961, H. T. PAGDEN (ML); 1 ♂, Selangor, Kuala Lumpur, Ampang reservoir, 13.V.1960, H. T. PAGDEN (ML); 1 ♂, Selangor, same locality, "caught at small feeder stream falling into lake", 16.I.1964, J. I. FURTADO (ML); Singapore I.; 1 ♂, Singapore (BM). — Sumatra: 1 ♂, Atjeh, Kutatjane, 21.III.1954, A. H. G. ALSTON (BM); 1 ♀, NE Sumatra, Asahan river, Tangga, 300 m, 2.VIII.1928, J. C. VAN DER MEER MOHR; 1 ♂, Ost Sumatra, no. 5451, A. HEYNE 1919, *V. amoena*, det. F. RIS (SMF); 1 ♂ 1 ♀, Padang Highlands, Kloof van Harau, I.1937, E. JACOBSON (ML); 2 ♂, Benkulen, Lebong Tandai, VII.1922 & IV.1923,

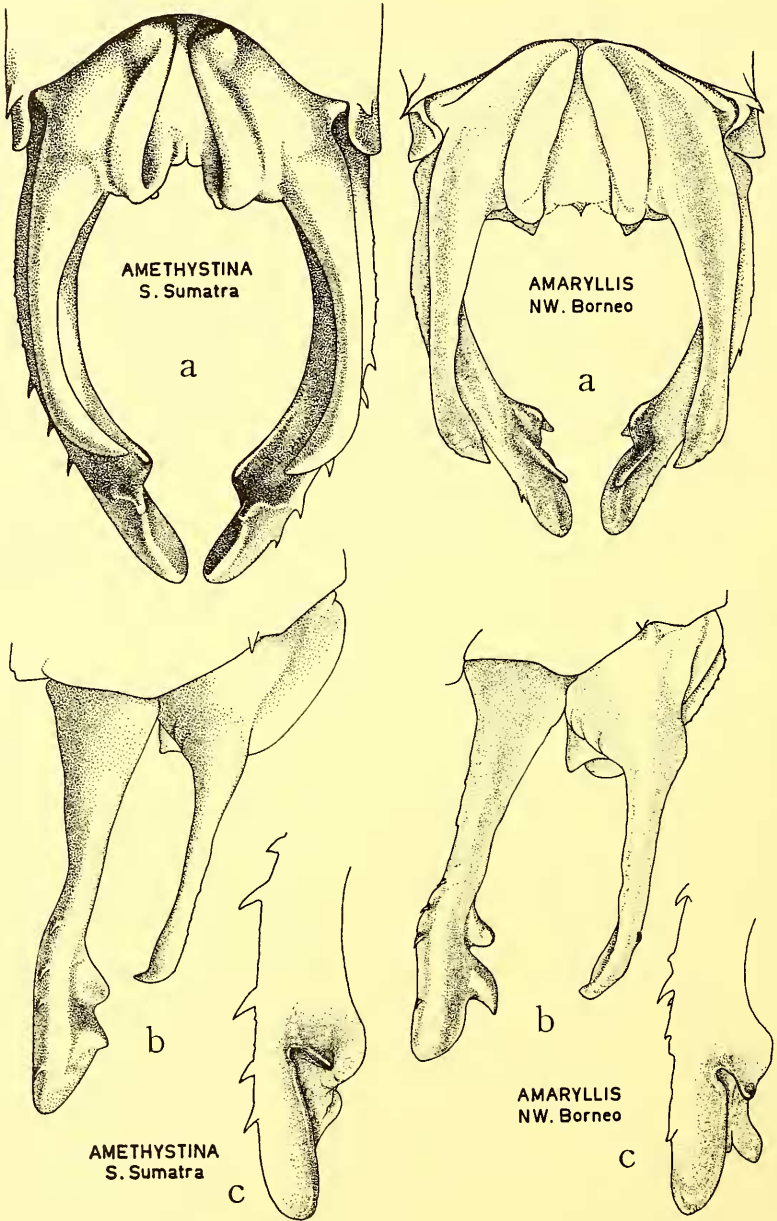


Fig. 6. Anal appendages of *Vestalis* species, a, ventral, b, right lateral view; c, apex of left superior appendage more enlarged, dorsal view slightly from within



C. J. BROOKS (BM); 2 ♂ 1 ♀, Benkulen, Muara Tenam, 250 m, 16—23.VI. 1935, M. E. WALSH (ML); 1 ♂ 1 ♀, Benkulen, Ranau Lake distr., Banding Agung, 27.X.1928, C. VAN STEENIS (ML); 1 ♂ 1 ♀ (holotype ♂ and allotype ♀; ♂ app. drawn, fig. 6, 9), Lampong distr., S. slope of Mt. Tanggamus, Gies-ting, 400 m, 24.XII.1934, M. A. LIEFTINCK (ML); 1 ♂, Lampong, Kedaton Estate, 14.IX.1932, H. R. A. MULLER (ML).

Female. — Of the same size and wing colour as *amoena* but even immature specimens can be distinguished therefrom by having a black labium, only a marginal hair-line of the palpi remaining yellow. Antenna with 2nd segment yellow anteriorly. The ventral surface of the thorax is likewise obscured, almost black in old adults, young females showing already a tendency towards obscuration of the lower surface. Some measurements are:

Penang I.: abd. + app. 35.0—40.0 mm, hind wing 32.0—35.0 mm

Sumatra: ——— 37.0—40.0 mm, ——— 33.0—36.0 mm.

This species is at present known only from southern Thailand, the Malay Peninsula and Sumatra, being replaced by *V. amaryllis* sp.n. in Borneo. As indicated in Table I, *V. amethystina* was repeatedly met with in company of *V. amoena*. Of the series taken by the Dajak collector at the waterfall near Trang (Peninsular Siam), 5 are *amoena* and 4 *amethystina*. The former were collected on 19, 21, and 23 July and 7 August, whilst the latter are all dated 20 July, 1935. Though not necessarily taken in exactly the same spot, these insects evidently occurred in close vicinity of each other. Anticipating that specific characters other than those already established should be detectable, these Trang specimens were thoroughly compared. However, the only additional feature by which the males can be held apart is found in the ground-colour of the body, which in *amethystina* is of a less vividly yellow tint than in *amoena*; also, in the former the thorax underneath is usually darker than in the latter. In the typical locality (i.e., Lampong district of South Sumatra), I collected both species the same day myself, but since at the time they were not recognized and held apart in the field, any specific ethological differences, if at all perceptible, were not noticed.

### *Vestalis amaryllis* spec. nov.

(fig. 2, 4, 6, 9a)

Material. — B a n g k a I.: 1 ♂, Mangkol, 20—100 m, 16.X.1949, and 2 ♂, Lubuk Besar, 20 m, IX—X.1949, A. J. KOSTERMANS (ML). — B o r n e o : 3 ♂, N Borneo, Tawau, Quoin Hill, Forest camp I, 2—3 mi. WSW of cocoanut Res. Sta., 3—20.VII.1962, Y. HIRASHIMA (BISH, ML); 1 ♂, N Borneo (Sabah), Bettotan, 10.V.1927, "22 mi. W by S of Sandakan up a river running into the head of Sandakan Bay; secondary growth low country" (penis dissected, coll. J. COWLEY); 1 ♂ 2 ♀, Bettotan, 24.VII (♂) and 25.VII (♀) 1927, *V. amoena*, det. F. F. LAIDLAW & J. E. H. ROBERTS (coll. J. COWLEY); 1 ♂, N Borneo (Sabah), Elopura (= Sandakan Bay), III.1884, *V. amoena* ex coll. & det. R. MACLACHLAN (BM); 1 ♂, SW N Borneo (Sabah-Sarawak boundary), Brunei Bay

Table II. Venational characters

	Antenodals		Postnodals		Nervures in quadrangle		Nervures in cubital space		Greatest width of hind wing		Average ratio distance base-nodus to nodus-apex	
	fore	hind	fore	hind	fore	hind	fore	hind	range	average	fore	hind
<i>amoena</i>	23—28	18—23	50—73	45—59	2—4	2—4	8—11	7—11	7.6—9.0	8.5	10 : 17.32	10 : 17.02
<i>amelbystina</i>	24—31	18—25	59—72	46—58	3—5	3—5	9—12	8—11	8.5—9.6	8.9	10 : 16.42	10 : 16.86
<i>amaryllis</i>	25—31	18—23	53—65	44—56	3—5	3—5	8—11	8—9	7.8—9.2	8.2	10 : 16.75	10 : 17.05
<i>annicola</i>	24—34	18—29	56—81	44—60	3—6	2—5	8—12	7—10	8.4—10.0	9.2	10 : 15.67	10 : 16.02
<i>ambitis</i>	25—29	20—24	58—72	44—58	3—6	4—5	9—11	9—11	8.1—8.4	8.27	10 : 16.15	10 : 15.87
<i>atrophba</i>	23—27	17—21	46—58	38—45	2—4	2—4	6—10	6—9	7.6—7.8	7.7	10 : 14.97	10 : 15.41
<i>anacolora</i>	26—28	21—22	60—63	53—54	4	3—4	10—11	8	8.8	8.8	10 : 15.50	10 : 16.30
<i>beryllae</i>	31—33	27—29	76—92	60—71	4—6	4—6	10—12	10—13	8.2—9.2	8.7	10 : 19.20	10 : 18.50

area, Dent Province, Mt. Marapok, collector G.<sup>1</sup>) (ML); 5 ♂ 1 ♀ (sub *amoena*), labelled "Labuan Borneo" or "Labuan" (yellow, DE SELYS' writing) (IRSN); 1 ♂, Labuan, Borneo, *V. amoena* Hag. ♂, ex coll. & det. H. ALBARDA (MA); 1 ♀ (def.), "Labuan/Borneo", "*Vestalis amoena* Hag. ♀ Labuan" (yellow labels, DE SELYS' writing) and "Hagen" (printed) (MCZ); 1 ♂ 1 ♀, Labuan, Borneo, ex coll. SELYS, *V. amoena* det. F. RIS (SMF); 3 ♂ 3 ♀, Sarawak, Kuching, 9—31.I, 10.II and 7.VIII.1896, ROLLE vend., *V. amoena*, det. F. RIS (SMF); 2 ♂ 1 ♀, SW Sarawak, NE slope of Mt. Penrissen, low country, Tebang, 6.IX.1958, T. C. MAA (ML, BISH); 5 ♂ 1 ♀ (including holotype ♂ and allotype ♀; app. drawn, fig. 6, 9a), W Sarawak, slope of Mt. Santubong, 30.IX.1950, M. A. LIEFTINCK (ML); 3 ♂ 3 ♀, East Borneo, Sangkulirang distr., Kariorang and Batu Besi, low country, 12.III.1937, J. W. QUARLES DE QUARLES and V—VI.1937, M. E. WALSH (ML); long series (both sexes, one ♂ penis drawn, fig. 2), Central East Borneo, Kutai, Samarinda area, Belajan valley, kali Bengen, Tabang, 125 m, VIII—IX.1956, A. M. R. WEGNER et al. (ML, MCZ); 1 ♂ 1 ♀, Central E. Borneo, Kutai, upper reaches of Mahakam river, Sungai Telen valley, Long Hut, 130 m, no. 37, 17.VIII.1925, and Long Petak, 440 m, no. 70, no date, H. C. SIEBERS, M.O. Borneo Exped. (ML); 4 ♂, Southeast Borneo, Kandangan, Ampah, 0—20 m, IV—V.1948, LIEM SWIE LIONG (ML), 1 ♂ 1 ♀, "Z. & O. Afd. Borneo, Kap. Benschop" (old round label) (ML); 1 ♀, West Borneo, Singkawang area, Piong San road, 9.XII.1931, L. COOMANS DE RUITER (ML). — B a n g u e y I. (Banggi), Balabac Strait: 1 ♂, Bangey, Ins. nördl. Borneo, W. KEDENBURG, ded. 20.VII.1894, *V. amoena* Hag., det. M. A. LIEFTINCK 1928 (ML, from series in ZMH). — B a l a b a c I.: 1 ♂ (semiad.), Balabac, no. 31280, A. EVERETT (SMF).

Female. — Similar to *amethystina* though light markings less extensive and more frequently obscured. Antenna with second segment yellow anteriorly. Colour of labium, lower parts of thoracic pleurae and ventral surface apparently variable. In common with *V. amoena* and *amethystina*, the wings become rather strongly tinted a greyish or yellowish brown in aged individuals.

As in *V. amoena*, there is much individual variation in the relative lengths of abdomen and hind wing, the difference fluctuating between 2.5—5 mm (Table III).

The specific identity of some females must remain uncertain. The dimensions of those collected in association with males are:

<sup>1</sup> Mr. TOM HARRISON, Curator of the Sarawak Museum (Kuching), kindly informs me in a letter that Mt. Marapok (near Merapok) "is a set of lower hills, up to 3000 ft. high, running behind the Mengalong and Lawas rivers across the Sabah-Sarawak border as outliers on the seaward side of the larger Crocker range. Sandstone with some limestone pockets". This information is corroborated by the botanist Dr. W. MEYER, of Sandakan (Sabah), who wrote me that Mt. Marapok (rect. G. Masatoh?) is a hill north of the Lawas and its tributary Sungai Mesatoh, situated just south of the south-west border of Sabah. According to Mr. HARRISON, the collector "G" might well have been F. H. H. G. GUILLEMARD, the locality being only one day from Brunei Bay, where GUILLEMARD went in the cruise of the "Marchesa" early in April, 1883. However, there is nothing in vol. II of "The Cruise of the Marchesa" (1886) to justify this supposition.

Labuan I. : abd. + app. 36.5—37.2 mm, hind wing 31.5—34.0 mm

Borneo ——— 33.5—41.5 mm, ——— 29.5—36.5 mm.

Has been found associated with *V. amoena* on Bangka Island and keeping company with that species in no less than four widely different localities in Borneo (Table I). Males are easily distinguished by the key characters although one example from Labuan I. is exceptional on account of its partly yellow labium and the great amount of yellow on the thoracic sides and underneath. In regard of markings it is, in fact, indistinguishable from *amoena* originating from the same small island. Some individuals have several duplicated cells in the proximal part of the space  $Cu_1$ — $Cu_2$  of the hind wings. More venational characteristics are given in Table II.

Of all members of the group this new *Vestalis* seems to find its nearest relative in *V. amethystina* sp.n., which it resembles most closely in the shape of the superior appendages.

Table III. Measurements

	Locality	Total number measured	Length of abdomen		Length of hind wing	
			Range	Average	Range	Average
<i>amoena</i>	Type	1	—	—	34.5	34.5
	P. Tioman	2	46.0—48.0	47.0	35.0—37.2	36.1
	Malaya	6	42.2—45.0	43.8	32.8—34.7	33.7
	Sumatra	25	44.2—46.7	45.3	33.7—36.5	34.9
	Bangka	3	39.0—43.5	40.8	29.0—32.3	30.1
	Billiton	1	43.7	43.7	31.3	31.3
	Borneo	34	39.0—49.0	43.6	30.5—36.4	33.0
	Whole range	72	39.0—49.0	44.5	29.0—37.2	33.4
<i>amethystina</i>	Malaya	10	42.0—46.9	43.8	31.5—36.0	33.2
	Sumatra	10	42.7—48.0	45.8	32.0—37.0	35.0
	Whole range	20	42.0—48.0	44.8	31.5—37.0	34.1
<i>amaryllis</i>	Bangka	3	41.2—43.4	42.3	30.8—32.2	31.5
	Borneo	56	40.4—48.0	44.2	30.5—36.0	33.2
	Banguey	1	43.8	43.8	33.8	33.8
	Balabac	1	42.5	42.5	32.4	32.4
	Whole range	61	40.4—48.0	43.2	30.5—36.0	32.7
<i>annicola</i>	Borneo	12	41.4—51.0	47.2	31.0—39.0	35.7
<i>amabilis</i>	Borneo	4	44.0—46.0	45.0	32.0—34.2	32.9
<i>atropha</i>	Borneo	3	40.0—43.0	41.6	30.0—31.0	30.5
<i>anacolosa</i>	Borneo	1	48.0	48.0	36.0	36.0
<i>beryllae</i>	Borneo	7	63.0—73.5	66.4	35.0—41.5	38.0



*Vestalis amabilis* spec. nov.

(fig. 4, 5, 9)

Material. — B o r n e o : 3 ♂ 3 ♀ (ad., including holotype ♂ and allotype ♀), SW N Borneo (Sabah-Sarawak boundary), Brunei Bay area, Dent Province, Mt. Marapok, collector G., one ♂ and ♀ with label *Vestalis amoena* ♂, det. R. MARTIN (ML); 1 ♂ (ad.), NE Sarawak, Mt. Dulit, Borneo bor. (ML).

Male. — Immediately distinguished from *V. amoena* by the longer appendix inferior and the black labium. Also, the yellow spot at the base of the mandible is small and isolated, subtriangular in outline, while the 2nd antennal segment is either unmarked or carries a small basal spot anteriorly. Lastly, the lower parts of the thorax are much obscured, in one specimen even the yellow line bordering the second lateral suture has disappeared. Several other species, of course, do resemble *amabilis* very closely in colour, but in doubtful cases the shape of the appendages is conclusive. For neural characters and measurements, see Table II and III.

Female. — The three specimens attributed to this species all have the labium black but the yellow line bordering the palpi outwardly is broader than in the male. The labrum has a pair of widely separated yellow spots. Second antennal segment yellow anteriorly. There is much yellow colouring on the infraepisternites and lower parts of metapleurae, the stripe joining the second suture being twofold. Under surface obscured, not quite black, pruinulent blue.

Abd. + app. 37.5—39.0 mm, hind wing 33.5—33.8 mm.

Evidently a rare species restricted to certain parts of Borneo but keeping company where found with *amaryllis*, *amnicola*, *atropha* and *beryllae* (see Table I and maps, fig. 4).

*Vestalis amnicola* spec. nov.

(fig. 4, 7, 9)

Material. — B o r n e o : North Borneo (Sabah), 1 ♂ (ad., holotype), Kina Balu, coll. STAUDINGER, acq. 1903, with label *Vestalis amoena* Selys, det. R. MARTIN (ML); 1 ♂ (app. drawn, fig. 7, 9), SE slope of Mt. Kinabalu, 1650 ft., no. 21, Ranau, 6.X.1958, T. C. MAA (ex BISH, ML); 1 ♂ (ad.), Kina Balu, N Borneo, 1.1894, leg. EVERETT, no. 5436 (SMF); 2 ♀ (1 juv.), same locality and dates, nos. 31279 and 31278 (SMF); 1 ♂, Kina Balu /91/ 161 (BM); 2 ♂ (one with intermediate abd.-segments missing), Kinabalu, STAUDINGER & BANG-HAAS vend., *V. gigantea* Förster, det. F. FÖRSTER (coll. J. COWLEY); 1 ♂, Kinabalu, 1914, J. C. MOULTON, *V. amoena*, det. F. F. LAIDLAW, ex coll. LAIDLAW & ROBERTS (coll. J. COWLEY); 1 ♂, Lewpu Aga House (Sandakan area?), 7.X.1920, *V. amoena*, det. F. F. LAIDLAW, ex coll. LAIDLAW (coll. J. COWLEY). 1 ♂, Sarawak, Mt. Dulit, R. Koyan, 2500 ft., 20.XI.1932, riverside, primitive forest, Oxford Univ. Exped., B. M. HOBBY & A. W. MOORE, H 619 (BM); 1 ♂, Sarawak, Mt. Dulit, 25.X.1932, house clearing, native collector, same exped. as before (BM).

Male. — Apart from the characters found in the anal appendages, the male of this new species can be recognized from its allies by (1) slightly more robust build, (2) closely reticulated wings and higher nodal index, and (3) more abruptly

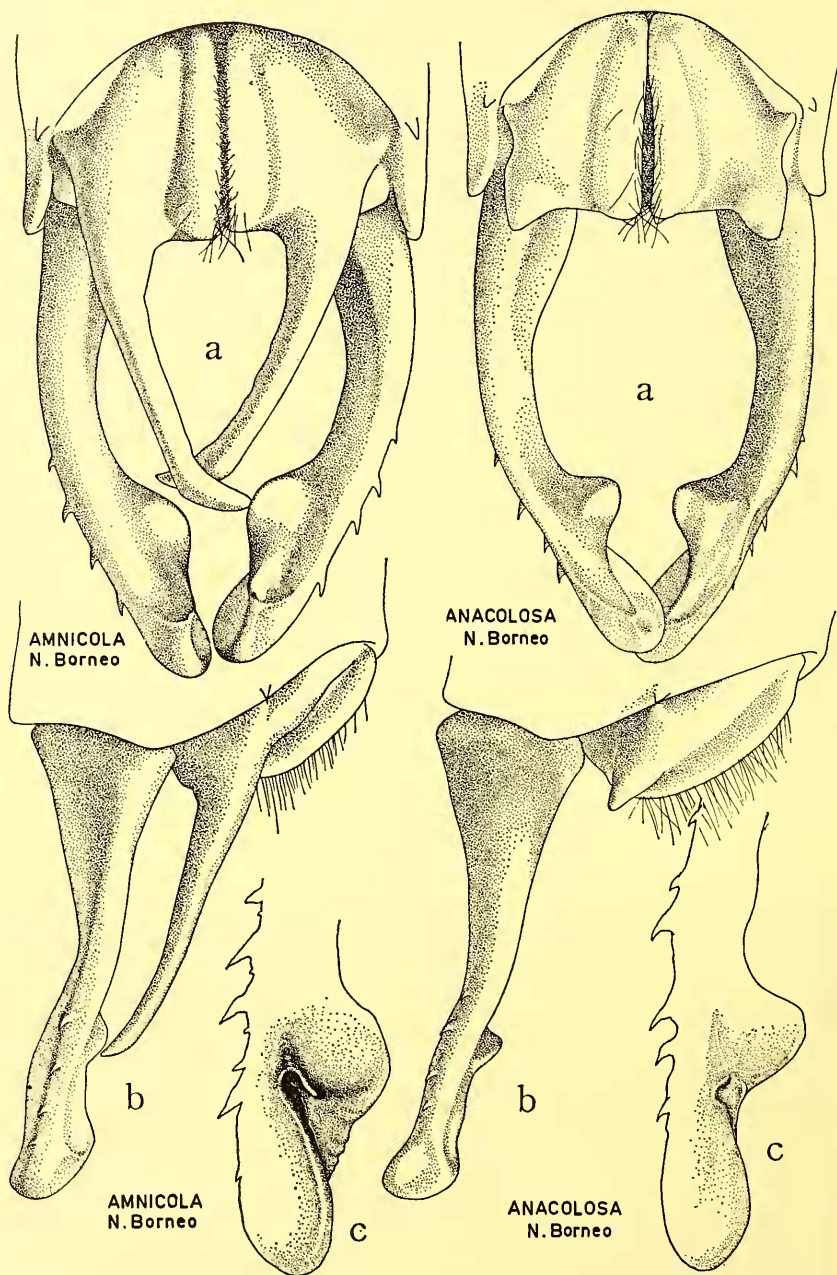


Fig. 7. Anal appendages of *Vestalis* species from Borneo. a, ventral, b, right lateral view; c, apex of left superior appendage more enlarged, dorsal view

broadened wings, the widest point of both fore and hind wing lying at a point a little beyond the level of the nodus, hence further distad than in the other species. There are also more divided cells between main sectors and supplements, the basal part of the  $Cu_1$ — $Cu_2$  area being a little wider than usual with more divided cells between them for a variable distance; in the right hind wing of one paratype (from Ranau, Mt. Kinabalu) this area for almost the whole length is two-celled, with 2—3 marginals. See also Table II.

For a colour description of the male, see *atropha* and *anacolosia*. All agree in having only a basal spot of yellow at the anterior face of the second antennal segment, and in the great majority the labrum is unspotted and distinctly metallic green. In the type the abbreviated metepimeral stripe joining the second suture is perfectly straight, rather broad though subinterrupted near its upper extremity, and there is also a small mesinfraepisternal spot.

The dimensions vary considerably in our series: the smallest male is from Lewpu Aga House (alt.?), measuring 41.4 mm for the abdomen, 33.5 mm for the hind wing. The largest males are amongst our series from Mt. Kinabalu and Mt. Dulit; no correlation exists between abdomen and wing lengths, and intermediate sizes are present from both localities. Many adults have the borders and extreme apices of wings markedly enfumed, the membrane itself remaining hyaline. Table III.

Female. — Only two examples of this sex can be assigned to *annicola* with reasonable certainty. The labium is coloured as in the male. In one the labrum is yellow with a mid-basal point of black and a black anterior border, whilst in the other only a pair of transverse yellow spots are present.

Abd. + app. 40.0 mm, hind wing 35.0—35.2 mm.

### *Vestalis atropha* spec. nov.

(fig. 4, 8)

Material. — Borneo: 1 ♂ (ad.), Sarawak, foot of Mt. Dulit, junction of rivers Tinjar and Lejok, 12.XI.1932, secondary forest, native collector, Oxford Univ. Exped., B. M. HOBBY & A. W. MOORE (BM); 1 ♂ (ad.), Sarawak, Mt. Dulit Trail, 10.VIII.1932, primitive forest, over stream, same exped. & collectors (BM); 1 ♂ (ad.), Sarawak, E of Mt. Dulit, Sungai Akah, 1.X.1920, collector? *V. amoena*, det. F. F. LAIDLAW, ex coll. LAIDLAW (coll. J. COWLEY); 3 ♂ 1 ♀ (ad.), sub *amoena*), "Sarawak", one with affix "Penrissen" (unknown handwriting) (IRSN). Holotype: ♂, Sarawak, Mt. Dulit Trail, 10.VIII.1932, Oxford Univ. Exped. (BM); paratypes of both sexes in (BM), (ML), (IRSN) and coll. J. COWLEY.

Male. — Labium black, yellow streaks only along outer margin of palpiger and basal half of first palpal segment. Mandible-bases with isolated yellow spot, very small and circular in the type, larger and rather more oval in the paratypes. Labrum black with faint metallic green gloss; anteclypeus obscured. Rest of head brilliant emerald green, the rear only feebly metallic and slightly pruinulent. Antenna black, second segment unmarked (type), or with roundish basal spot anteriorly (paratypes).

Synthorax with no other yellow markings than a metepimeral line bordering

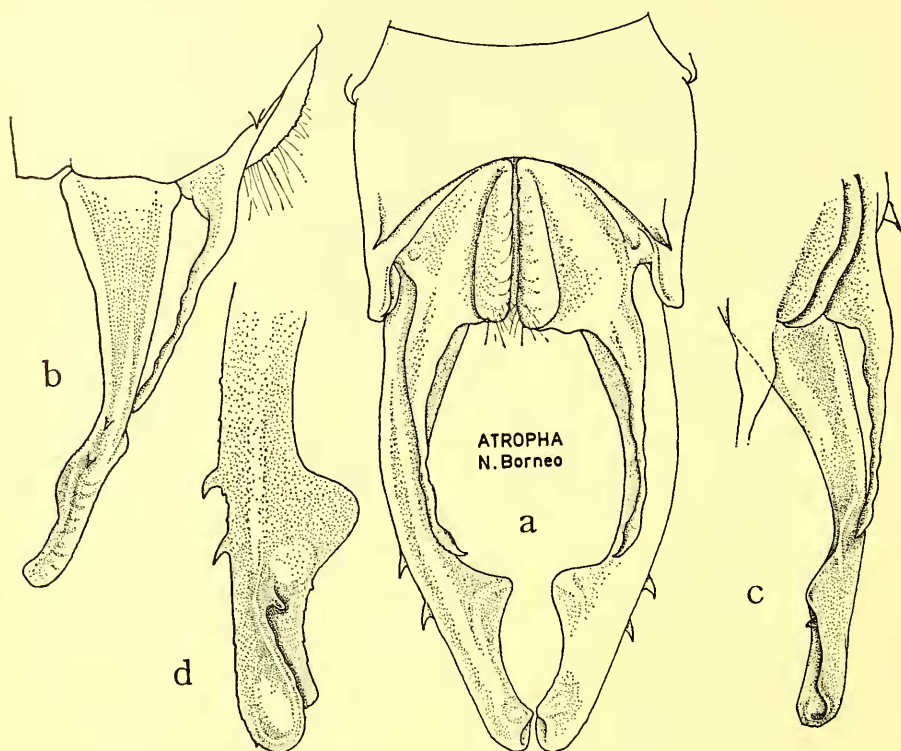


Fig. 8. Anal appendages of *Vestalis atrophpha* sp.n., ♂ holotype. a, ventral, b, right lateral, c, intero-ventral view; d, apex of left superior appendage more enlarged, dorsal view

the second lateral suture and a mere streak at latero-ventral border, the former being widest and somewhat broadened ventrad in the type, shorter and linear in the paratypes; lower areas of the sides wholly black (one paratype) or with vestigial mesinfraepisternal spot (holotype and one paratype). Thorax entirely black ventrally and like the lower pleural parts and coxae covered with light blue or grey-blue pruinescence.

Wings comparatively narrow and more pointed than in the allied species; apices and posterior margin of membrane slightly smoky or entirely hyaline. Neuration (Table II); there are one or two divided cells between  $Cu_1$  and  $Cu_2$  in the hind wings of the type but in the others there is only a single row.

Abdomen black with the usual brilliant peacock green gloss on the basal segments. Penis not differing from that of the other members of the group but anal appendages of characteristic shape and quite similar in all individuals (fig. 8).

Female. — Labium coloured as in the male. Base of mandible with large yellow spot surrounded by black. Labrum marked with a heavy T-shaped greenish black spot; a median transverse streak of yellow also on anteclypeus. Basal half of second antennal segment yellow anteriorly. Colour-pattern of synthorax as in most



other species, the lower parts with much yellow colouring, the line joining second suture twofold; ventral surface obscured in the middle.

$$\text{Nodal index } \frac{47.23.22.46;}{40.16.18.41} \quad q \quad \frac{3.3;}{2.3} \quad Cux \quad \frac{7.7}{8.7}.$$

Dimensions. Male, see Table III. Female, abd. + app. 36.0 mm, hind wing 32.0 mm.

This new species is the smallest of the *V. amoena* group and can be at once distinguished from its allies by the long upcurved superior anal appendages and the curiously emaciated form of the inferior pair. The name is an allusion to the atrophied condition of the latter. The wings have a more open venation and are a trifle narrower and more pointed than in any of the others; the more distal position of the nodus is an additional feature of the insect.

### *Vestalis anacolosa* spec. nov.

(fig. 2, 4, 7, 9)

Material. — North Borneo: 1 ♂ (holotype, app. & penis drawn, fig. 2), Sabah, E slope of Mt. Kinabalu, 10 miles N of Ranau, 1570 ft., Paring, 9.X.1958, T. C. MAA (ex BISH, ML).

As far as colour and markings are concerned, the unique specimen of this very distinct species does not seem to differ from fully adult examples of *V. amabilis*, *amnicola* and *atropa*, which are all of them equally dark-coloured insects, even the labrum being nearly always unspotted with yellow. For the sake of completeness the following characters are given in addition to those mentioned in the tables and key.

Labium black, palpiger and basal half of first palpal segment narrowly bordered with yellow, these tiny crescents sharply defined. Mouth-parts and adjoining parts of face black, genal area very shiny, anteclypeus dull. A large, isolated, subrotundate yellow spot at base of mandible. Head otherwise black with the usual brilliantly metallic emerald green shine, only the labrum and rear of the head but slightly lustrous, the latter somewhat pruinosed. Antenna black, anterior face of second segment with a pear-shaped basal yellow spot extending up for  $1/2$  to  $1/3$  the whole length. Yellow marks on thoracic segments restricted to tiny spots filling up the lower edges of the infraepisternites; a straight metepimeral line, incomplete on both ends, runs along second lateral suture. These lower parts, as well as the ventral surface and the coxae of legs, are covered with grey-blue pruinescence concealing most of the surface.

Wings rather pointed, membrane entirely hyaline. Neuration (Table II) without peculiarities; no duplicated cells between  $Cu_1$ — $Cu_2$ .

Abdomen lacking yellow markings; colour black, segm. 1—3 and base of 4 metallic green, succeeding segments and anal appendages almost lustreless. Penis (fig. 2). Appendages (fig. 7, 9).

Female unknown.

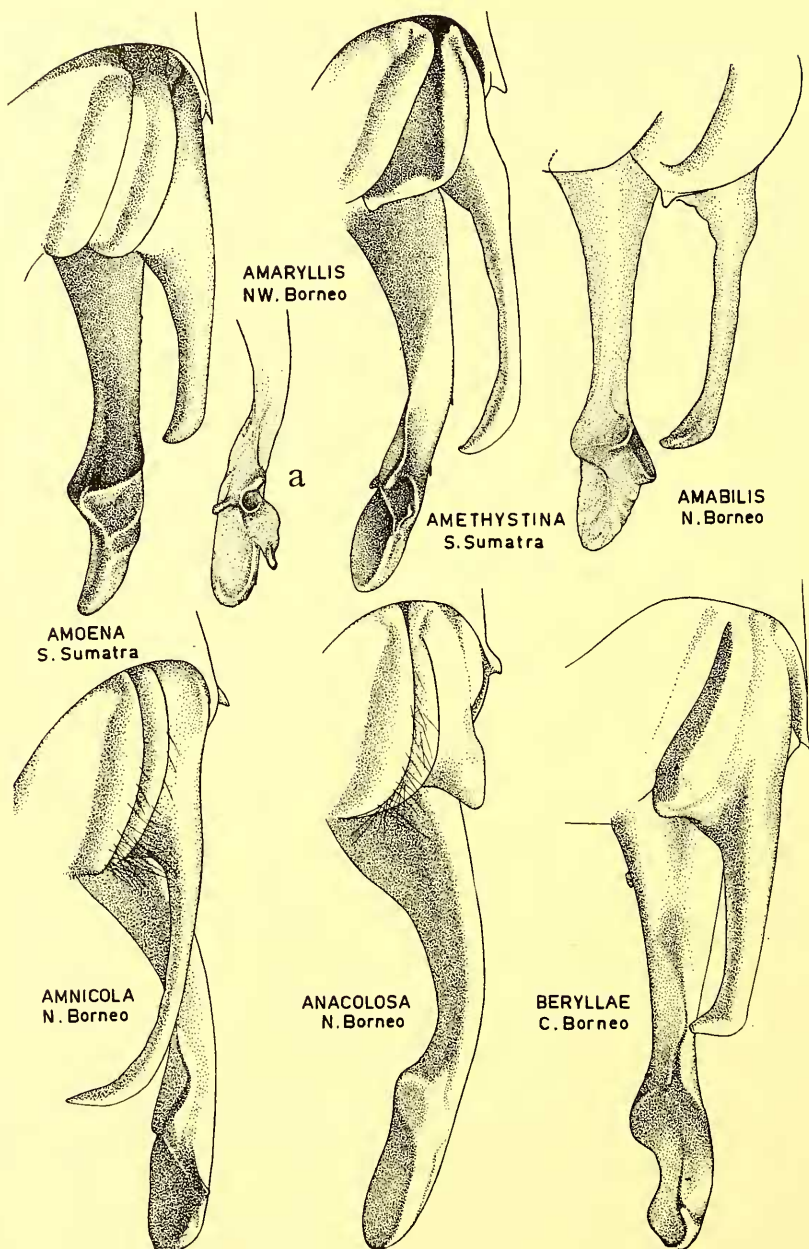


Fig. 9. Left pair of anal appendages of *Vestalis* species, oblique intero-ventral view; a, interior view of apex of right superior appendage of *V. amaryllis* sp.n., Mt. Santubong

*Vestalis beryllae* Laidlaw, 1915

(fig. 4, 9, 10)

Material. — Borneo: 1 ♂ (ad., holotype), labelled "Mt. Merinjak<sup>1</sup>), 29.5.14. / J. C. Moulton Type MSS" (BM); 1 ♂, Borneo (BM); 3 ♂ (ad., one with abd.-segm. 7—10 missing), W Sarawak: "Sarawak/53 Mt. Penrisen, Sarawak" (yellow, DE SELYS' writing), "*Vestalis elongata* S. mss." (ditto) (IRSN); 2 ♂ (1 juv.), Kinabalu, Borneo, ex coll. MACLACHLAN (BM); 1 ♀ (ad., allotype by present designation), Kina Balu, N Borneo, 1.1894, leg. EVERETT, *V. amoena* ♀, det. F. RIS, ded. R. MARTIN (SMF); 1 ♂ (ad.), NE Sarawak, Mt. Dulit, Borneo bor., *Vestalis elongata* nov. spec. (R. MARTIN's writing) (ML); 1 ♂ (ad., app. drawn, fig. 10), Central Borneo, Sungai Mandai hills, Mt. Liang Kubung (cave) near Nangaraun, 800 m, 10.III—5.V.1894, J. BÜTTIKOFER (ML); 1 ♂ (juv., penis dissected, fig. 10), Central East Borneo, Kutai, upper reaches of Mahakam river, Sungai Telen valley, Long Hut, 150 m, no. 50, 23.VIII.1925, H. C. SIEBERS (ML).

Male. — Labium, trochantin and apex of mandible black, as are the genae and a narrow polished area extending from below upwards along margin of compound eye as a gradually narrowed line tapering to a fine point and ceasing at a level of the posterior ocelli. Labrum, base of mandibles and clypeus emerald green; labrum with an impressed black spot in the middle at base and centre of anteclypeus also black and lustreless. Clypeus transverse, somewhat protuberant and swollen medially, about  $2\frac{1}{2}$  times broader than deep; its anterior border rounded, the upper surface (postclypeus) transversely striate, moderately convex, with a shallow, dull black depression on either side. Second antennal segment metallic green, third segment dark bronze, flagellum black.

Pro- and synthorax metallic green, the carinae and sutural lines black as are also the lower parts of metapleurae including the second lateral suture. The metallic colour on either side of the latero-ventral border of metepimerum and second suture frequently acquire a more coppery tint. Ventral surface of thorax black, except the metasternum which is again metallic green, all parts more or less powdered with light blue. Legs black, the outer faces of all coxae metallic green to dark bronze.

Wings distinctly narrower and less expanded than in species of the *amoena* group, the postnodal portion lanceolate with bluntly rounded tips. Nodus more

<sup>1</sup>) Some difficulty was experienced in finding out the geographical position and altitude of the type locality of *V. beryllae* in Sarawak. The original description merely gives "Retuh" but the type-label indicates Mt. Merinjak, May 29, 1914. Dr. T. HARRISSON (in litt.) locates both of Mr. MOULTON's collecting places in the upper Baram river valley, over 50 miles distant from Mt. Murud in a northeasterly direction. A specimen of *Chlorogomphus dyak* Laidlaw is reported by its describer as having been taken by MOULTON on Mt. Merinjak on May 28, 1914, 2200 ft. It is evident, therefore, that *V. beryllae* in this area does not exceed the limits of the submontane forest zone. Other dragonflies collected by MOULTON about the same time and labelled "Mt. Murud" probably also originate further down the Baram and are from Murud Kechil, a much smaller peak than the true Murud, which was not climbed and explored until World War I by Messrs. E. MjöBERG and T. HARRISSON, the latter having corrected its position and altitude on the existing maps.

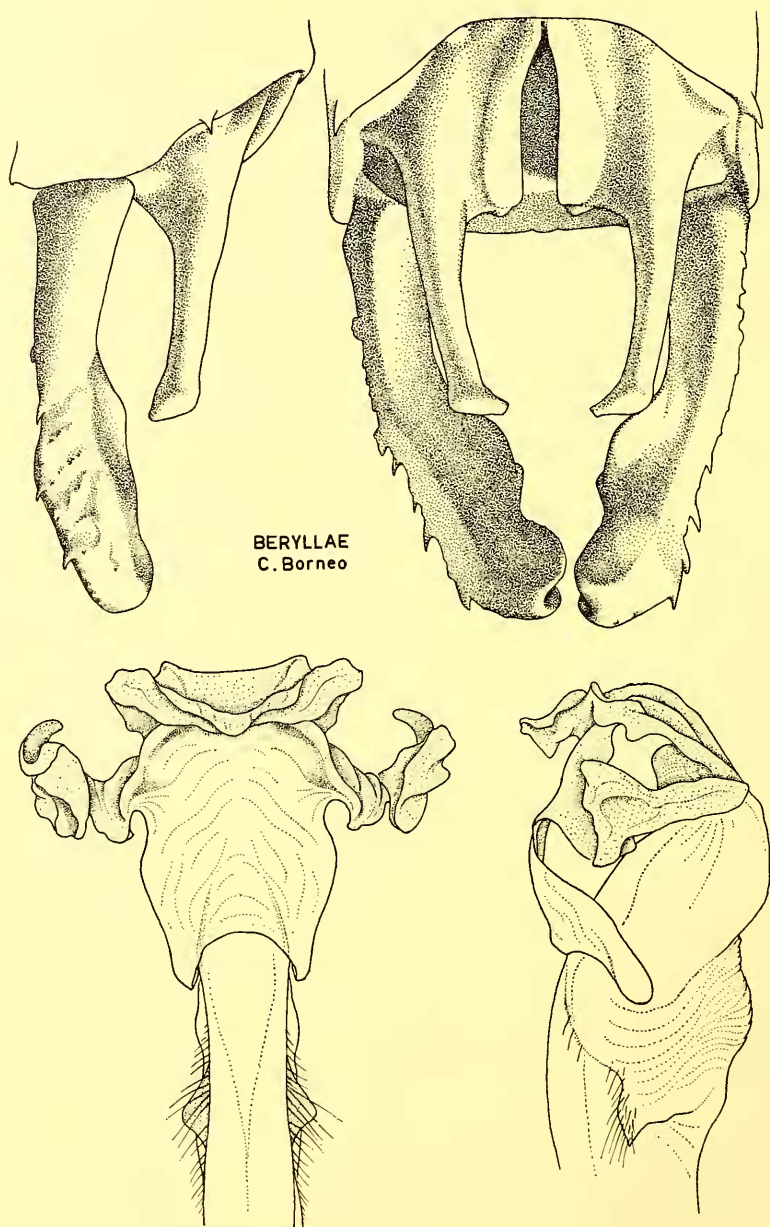


Fig. 10. *Vestalis beryllae* Laidlaw, ♂ Mt. Liang Kubung. Anal appendages, right lateral and ventral view, and apex of penis, ventral and right lateral view



recessed and main longitudinal veins straighter than in the *amoena* group of species. Neuration, see Table II; fore wing with one row of cells  $Cu_1$ — $Cu_2$ , this area in hind wing slightly expanded sub-basally, usually commencing with three or more single cells followed for a variable distance by two rows and with 1—3 marginal cells. Membrane of both fore and hind wings evenly and rather strongly tinged with yellow in mature examples, extreme apices moreover slightly enfumed along margin.

Abdomen long and slender, from the base of segm. 7 to the end of 9 gradually a little expanded and at the same time dorso-ventrally flattened. All tergites brilliant metallic peacock green above, a little less shiny beneath. Anal appendages black, dorsal surface of both pairs slightly metallic bronze but inferiors usually with distinct metallic green lustre ventrally.

Pens as described on p. 330 and in the key (fig. 10). Anal appendages, fig. 9, 10).

The measurements of the entire series of males are:

Mt. Merinjak (holotype)	abd. + app.	73.5	hind wing	41.5 mm.
Mt. Penrissen	—	71.0	—	42.0 —
Mt. Penrissen	—	70.0	—	40.0 —
Mt. Penrissen	—	—	—	39.0 —
Mt. Kinabalu	—	68.5	—	39.0 —
Mt. Kinabalu	—	63.0	—	37.8 —
Mt. Dulit	—	67.0	—	40.0 —
Mt. Liang Kubung	—	65.0	—	36.5 —
Long Hut	—	64.0	—	36.5 —
"Borneo"	—	64.0	—	35.0 —

Female. — The specimen is fully coloured and agrees with the male in all but the sexual characters. Head without any pale markings; mouth-parts black, the mandible-bases and labrum emerald green. Sutural stripes and lower parts of synthorax all deep black. Wings slightly tinged yellowish. Cross-veins in  $q \frac{4.4}{5.4}$ ; nodal index  $\frac{64.27.29.64}{53.24.26.58}$ ; Arculus very oblique, at  $Ax_{3-4}$  in all wings. In the

fore wing there is only a single row of cells  $Cu_1$ — $Cu_2$  but in the hinder pair there are several duplicated cells between these veins; also, whereas  $Cu_2$  in the fore wings is normal and flatly curved, this vein in the hinder pair is distinctly convex, approaching the condition found in *V. gracilis* Ramb. This is in conflict with an observation made by MAY (1935 : 213), whose statement only applies to the fore wing.

Dimensions: abd. + app. 49.0 mm, hind wing 40.0 mm, greatest breadth of hind wing 9.0 mm.

LAIDLAW's description of the colour and shape of the inferior anal appendages scarcely applies to the specimens before me. In July, 1964, I was able to compare these with the type in the British Museum and found that in all of them the inferior pair are more or less metallic green ventrally, the apices, though cylindrical, being rather abruptly inwardly curved.

As indicated earlier, the systematic position of this striking insect is puzzling.

Although agreeing with the typical members of the *V. amoena* series in many respects, it remains isolated structurally. Within the group it takes a position more or less comparable with that of the dark-winged *Neurobasis* (*Matronoides*) *cyaneipennis* Förster (also from Borneo) as opposed to the allied species-group of *N. chinensis* (L.). The most noteworthy features of *V. beryllae* are the extraordinary shape of the penis, the lack of yellow body-marks, and the slender form of body and wings. These characters are partly unisexual but decidedly striking. Unlike the aberrant *N. cyaneipennis*, the present species is not at all restricted to the higher altitudes of Borneo, but unfortunately nothing is yet known of its habits and life history.

#### IMMATURE STAGES

(fig. 11, 13)

The majority of the described Old World genera of Calopterygidae are now fairly well known from the ultimate instar larvae. Of the three Malaysian genera, the fullest account of *Vestalis* is the one given by RIS (1912) of *V. luctuosa* (Burm.) from Java. The characters of *Neurobasis chinensis florida* Hagen, also from Java, were summarized and illustrated more recently by LIEFTINCK (1955). The third and last Malaysian genus, *Echo* Selys, has not so far been described or figured.

I here offer camera lucida illustrations of full-grown examples of the *Neurobasis* just mentioned, as well as of *Echo uniformis* Selys and *Vestalis luctuosa* (Burm.), the last two from Sumatra. All were drawn from anaesthetized or freshly killed specimens collected between the years 1934 and 1941.

The three genera differ much between themselves in general appearance, *Neurobasis* approaching *Calopteryx* most closely in being of very slender form, with a small head and exceedingly long legs and caudal lamellae. *Vestalis* in every respect is more compactly built and has a broader head. Lastly, *Echo*, although possessing equally long legs and similarly shaped antennae, has a still larger and broader head, the whole body being more expanded. In this respect *Vestalis* takes a somewhat intermediate position between these two extremes (cf. fig. 11).

The structure of the labium shows corresponding differences in proportion. A comparison of this organ (fig. 12—13) reveals a deeply cleft median lobe in *Neurobasis* and *Vestalis*, the inner margin of the palpus carrying denticulations of two sizes. *Echo*, on the other hand, has a broader labium with less deeply incised midlobe, and a palpus with an evenly and more finely denticulate inner margin.

Analogous differences can be observed when comparing the shape of the caudal lamellae. Though in *Vestalis* the lateral gills bear a prominent mid-rib exteriorly, all three of them are plate-like, of the vertical lamellate type, whereas in *Echo* only the median gill is flattened, the lateral pair being triquetrous in cross-section with rows of short tubercular spines at the ridges. *Neurobasis* (and *Matrona* as well) takes a position between the former two genera in that the thickened median gill is spatulate towards the tip; otherwise they agree by having the lamellae of unequal length, strongly triquetrous and with denticulate carinae

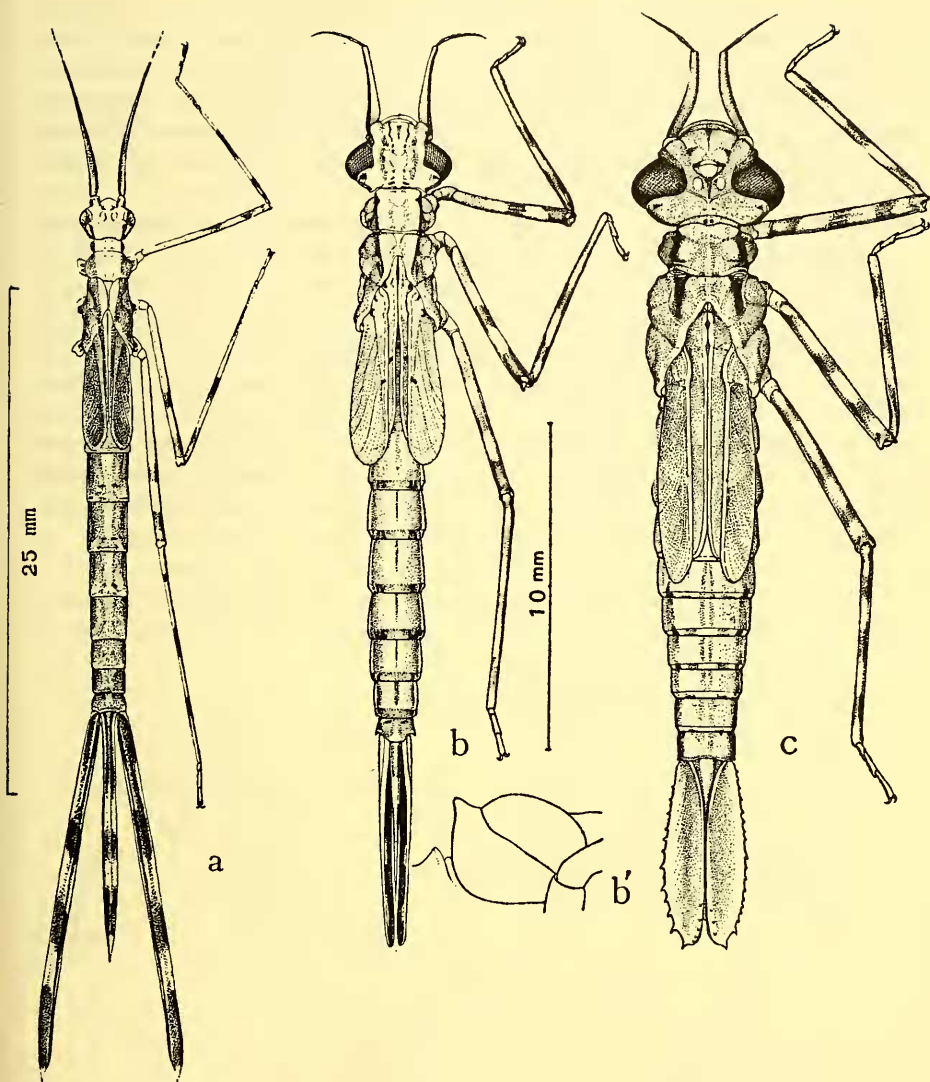


Fig. 11. Ultimate instar larvae of: a, *Neurobasis chinensis florida* Hagen, from West Java, Tjibarembang, 13.XI.1938 (after LIEFTINCK, 1955); b, *Vestalis luctuosa* (Burm.), South Sumatra, Wai Tebu, XII.1934; b', right lateral view of head more enlarged, showing postocular tubercle and base of antennae; c, *Echo uniformis* Selys, from SW Sumatra, SE slope of Mt. Dempo, 1100 m, X.1941. Fig. 11b and c, same magnification

(cf. LIEFTINCK, 1955, fig. 5—6). *Neurobasis* conforms to the larva typified by *Calopteryx*, whereas *Echo* more closely approaches the East Asiatic *Mnais* (ASAHINA, 1956) and the Ethiopian genus *Sapho* (FRASER, 1951). Both of the latter, like *Echo*, have at least the lateral caudal gills modified and triquetrous. Apparently no published description or figure exist of the well-known Ethiopian genus *Phaon*, whose larva presumably recalls *Vestalis* in general appearance, agreeing with it in the essential characters.

The material at my disposal of *Vestalis* larvae pertaining to the *amoena* group is rather meagre and from different sources, as follows:

Malay Peninsula: 1 ♀ ult, Penang I., Batu Feringgi, 28.II.1963, forest brook, M. A. LIEFTINCK; 1 ♂ 3 ♀ ult, 2 ♀ penult and 3 ex. younger stages, Perak, Plus river, Sungai Yum, 15.III.1933, M. W. F. TWEEDE; 1 ♀ exuvia, with freshly emerged imago, Selangor, Kuala Lumpur, Ulu Gombak, 16.III.1963, M. A. LIEFTINCK; 1 ♂ 1 ♀, penult, Johore, Tankak, 4.XI.1959, stream in rubber estate at foot of Mt. Ophir, close to Muar Reserve, 4.XI.1959, no. 68, D. S. JOHNSON; 1 ♀ ult, 1 ♀ penult, stream ca. 2 miles S of Suak, 10.VIII.1958, D. S. JOHNSON. — Borneo: 3 young larvae, S. Borneo, Sampit area, Pemantan, brook on peaty soil near tributary of Sampit river, low country, ult. VII.1959, M. A. LIEFTINCK. All specimens are in the Leiden Museum.

These individuals very nearly agree with the more remotely allied species *V. luctuosa*, of which I have a fair number of specimens collected in West Java and

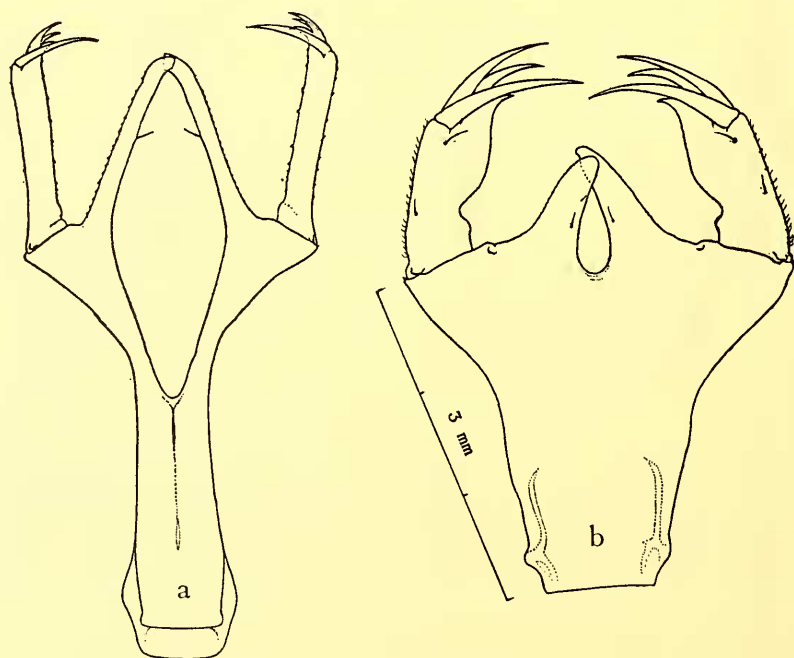


Fig. 12. Interior view of labium; a, *Neurobasis chinensis florida* Hagen, from West Java, Tjibarangbang, 13.XI.1938; b, *Echo uniformis* Selys, from South-west Sumatra, SE slope of Mt. Dempo, 1100 m, X.1941. Same magnification



South Sumatra. However, they can be at once distinguished from that species by the curiously obliquely truncated apex of the median caudal lamella (fig. 13), which in *luctuosa* is approximately of the same shape as the lateral pair (cf. RIS, 1912, fig. 24, with which our own specimens agree). This dissimilarity in the form of the caudal gills seems to be a feature common to all species of the *amoena* group, by which they can be easily recognized. RIS's description of the larva of *V. luctuosa* is very full, and I have been unable to detect any consistent differences between it and the *amoena* assemblage. The raised postocular tubercles, shown for *V. luctuosa* in profile view (fig. 11b'), are equally strongly developed in the *V. amoena* group, even the minute lateral ocellar warts, mentioned by RIS in his description of the *luctuosa* larva, being present in the specimens here treated. One of the few discrepancies is found in the shape of the median caudal gill, which in all specimens enumerated above is obliquely truncated apically, with a somewhat swollen dorsal margin and with the apex acuminate (fig. 13d). A further slight difference is found in the structure of the labium, the cleft of the median lobe in *luctuosa* being, perhaps, a little broader towards the bottom than it is in the *amoena* group, although I am doubtful whether this is a constant and reliable mark

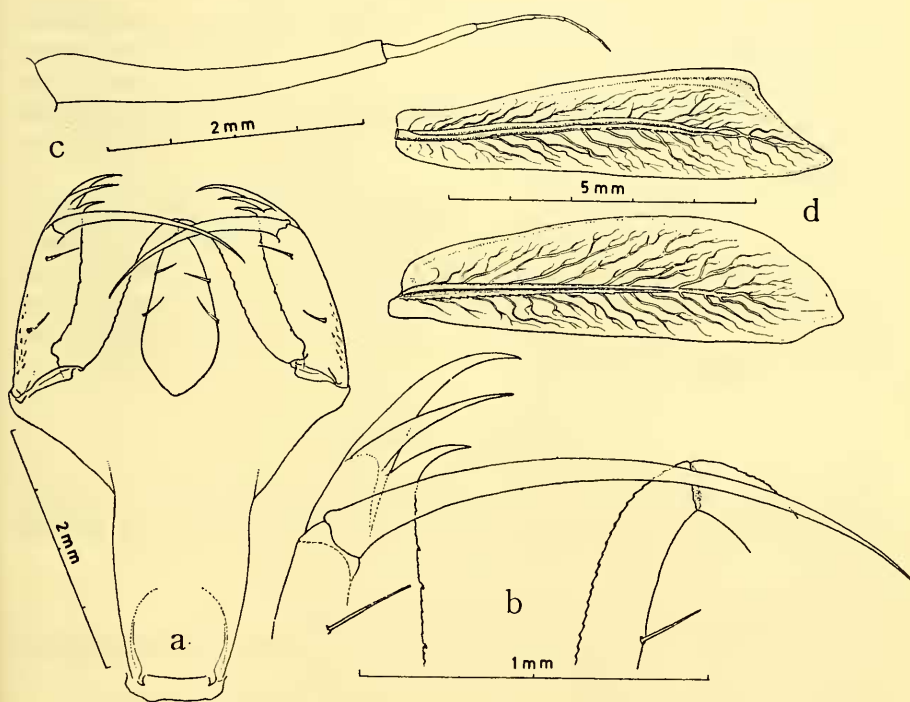


Fig. 13. *Vestalis* species, group *V. amoena* Selys. Larval structures, ultimate instar. a, interior view of labium; b, apex of labial palpus and median lobe, more highly magnified; c, right antenna; d, median and left lateral caudal gill, colour-pattern pigmentation not shown. Fig. 13a, b and d after specimen from Ulu Gombak, Malaya; fig. 13c after specimen from Batu Feringgi, Penang Island

of distinction. A characteristic feature of all *Vestalis* larvae is the great length and slender form of the end-hook at the labial palpus.

A peculiar feature of the antenna of these vestaline dragonfly larvae, which I have not found mentioned in the literature, is the presence of a vestigial — rarely incompletely developed — extra joint between the pedicel and the second segment. This intercalated minute segment is present in all individuals examined and is also shown in RIS's fig. 22 (loc. cit.) of the head of *V. luctuosa*. It is worth attention that the same structure occurs in the neotropical *Hetaerina macropus* Selys, well figured (though not mentioned) in a paper by GEIJSKES (1946, fig. 1). I have failed to find any trace of this additional segment in the larva of *Echo* and *Neurobasis*, which possess normal seven-segmented antennae.

I refrain from giving colour descriptions and measurements of the material in our collection. The body pattern of a Sumatran *V. luctuosa* is shown in fig. 11b, with which most of our "*amoena*" larvae agree. However, much variation exists in the development of dark bands and spots, including those ornamenting the gill lamellae. The young individuals I obtained from the almost black-bottomed rivulets in the peat marshes of southern Borneo, are considerably darker than the rest and have sharply defined black-ringed legs.

Measurements of structural details are given with the illustrations.

The specific identification of the present larvae must remain somewhat doubtful. When in the field, unfortunately no particular attention was paid to the imagines of the clear-winged members of the *V. amoena* group as it was not foreseen that more than one common and widespread species existed anywhere in the Malaysian Subregion. Hence no attempts were made to associate larval forms with adults occurring in any particular locality.

The larva from Penang Island was dredged up from among leafy trash in a shady brook at the banks of which adult individuals of *V. amethystina* were also taken. The transforming female from Ulu Gombak (Selangor) I collected at the same place where Mr. FURTADO took a male of *V. amoena* one year later. The immature larvae I obtained from a forest brook near Pemantan are possibly also *amoena*, this being the only member of the group collected in that locality.

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The specimens recorded in this paper are deposited in the collections of various institutions for which abbreviations have been used in the text; these are specified as follows:

BISH — Bernice P. Bishop Museum, Honolulu, Hawaii

BM — British Museum (Natural History), London

Coll. J. COWLEY — Personal collection of Mr. JOHN COWLEY, Weston-super-Mare, Somerset

IRSN — Instituut Royal des Sciences Naturelles de Belgique, Bruxelles

MA — Zoölogisch Museum, Amsterdam

MCZ — Museum of Comparative Zoology, Harvard University, Cambridge, Mass.

ML — Rijksmuseum van Natuurlijke Historie, Leiden

SMF — Natur-Museum u. Forschungs-Institut Senckenberg, Frankfurt a.M.

ZMH — Zoologisches Staatsinstitut und Zoologisches Museum, Hamburg.

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